

1968 - Volume 7, Number 1

DECUSCOPE

DIGITAL EQUIPMENT COMPUTER USERS SOCIETY

2008
MEMBERS
1967

850
MEMBERS
1966

426
MEMBERS
1965

109
MEMBERS
1964

HAVE YOU SENT IN YOUR ABSTRACT FOR THE DECUS SPRING SYMPOSIUM IN PHILADELPHIA ?

IF NOT, THERE MAY STILL BE TIME. LOOK THRU THE PILE OF PAPERS ON YOUR DESK FOR THE GREEN FLYER TITLED - "CALL FOR PAPERS"; COMPLETE THE SECTION CALLING FOR AN ABSTRACT AND MAIL IT TODAY TO THE DECUS OFFICE. IF YOU HAVE SYSTEMS PROGRAMMING TO TALK ABOUT, COMPLETE THE SHEET REFERRING TO WORKSHOP PARTICIPATION.

IN CASE YOU HAVEN'T HEARD, THE SPRING SYMPOSIUM WILL BE HELD AT THE BELLEVUE STRATFORD HOTEL IN PHILADELPHIA ON APRIL 26TH AND 27TH. SESSIONS WILL BE HELD ON THE FOLLOWING APPLICATION AREAS: BIOMEDICINE, TYPESETTING, EDUCATION, AND HIGH ENERGY PHYSICS.

THE FOLLOWING WILL SERVE AS CHAIRMEN FOR THEIR RESPECTIVE SESSIONS:

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STANFORD UNIVERSITY
STANFORD, CALIFORNIA

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PHILADELPHIA, PENNSYLVANIA

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CAMBRIDGE, MASSACHUSETTS
(DECUS PRESIDENT)

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TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

MODULES: SYPKO ANDREAE
LAWRENCE RADIATION LABORATORY
BERKELEY, CALIFORNIA

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NOTE

The volume number of the last issue of DECUSCOPE was erroneously omitted. The issue (Season's Greetings on the cover) should be numbered Vol. 6, No. 6.

DECUS PROGRAM LIBRARY NOTE

DUE TO THE LARGE BACKLOG OF REQUESTS FOR PROGRAMS ANNOUNCED IN THE LAST ISSUE OF DECUSCOPE, WE ARE NOT INCLUDING ANY ADDITIONS IN THIS ISSUE. WE ARE, HOWEVER, PLANNING ON SENDING OUT AN ANNOUNCEMENT OF NEW PROGRAMS AROUND THE MIDDLE OF MARCH. THIS WILL ENABLE US TO "CATCH UP" ON REQUESTS BEFORE MORE COME "POURING IN". PLEASE BEAR WITH US UNTIL THEN.

THE DECUS PROGRAM LIBRARY

PRESIDENT'S LETTER

As new President of DECUS, I would like to report to the membership about some new developments in the Society.

The newly installed Executive Board has vacant positions. My election to the presidency created a vacancy in the office of Programming Chairman. To this office I have appointed a present board member, Mike Wolfberg, the previous Publications Chairman. In addition to this, newly elected Nancy Lambert has been unable to take office as Recording Secretary due to a new job unrelated to DEC hardware; so anyone interested and able to contribute actively to DECUS administrative affairs by serving on the Board may contact me for further details.

With the rapid growth of the Society, it is becoming apparent that some changes may be in order in Executive Board structure. We need more help in keeping the high momentum that we have had for the past few years. I feel that these are two main areas of immediate need: Programming and Meetings. I have asked Mike Wolfberg to structure the Programming Committee along product lines. This has been started with Mike reviewing PDP-8 software as it comes into the DECUS Library. Dave Friesen of M.I.T. is doing the same for PDP-6/10 software, and Mike is looking for someone to review PDP-7/9 software.

The last couple of technical meetings have been tremendous undertakings for our previous Meetings Chairman, Don Molony. The meetings have had about two hundred attendees, and this number could easily double in the next few meetings. Therefore, I have asked Phil Bevington to look for people to work on the Meetings Committee, especially to help with the East Coast meetings. Anyone interested in working on this Committee should contact Phil at Stanford.

Also on the subject of meetings, we have received good reports about our last meeting in Anaheim, in particular the handling of the workshops. Next time we intend to expand on this plan and schedule workshops for each product line and modules. Anyone who wishes to present a paper pertinent to any one product line (e.g., a new assembler) will be given a chance to do so at an appropriate workshop. The remainder of the meeting will be for application-oriented papers in Education, High Energy Nuclear Physics, Biomedicine, and Typesetting. We are organizing these sessions well in advance this time, along with session chairmen to set up and run these sessions. Hopefully, we will have a very useful meeting in Philadelphia.

As a final note, I wish to report on the new format of the Board Meetings initiated in January. We are now having meetings with everyone present by using a WATS line between DECUS headquarters in Maynard and Stanford University. The first meeting was very successful, and we hope to continue with the system.

We, on the Executive Board, are most happy to receive suggestions from the membership. Our purpose is to have a better and more useful Society. We are growing rapidly and want to keep our momentum through enlightened administration.

Richard J. McQuillin
DECUS President

John B. Goodenough
President - 1966-1967

On the cover of this issue we have tried to illustrate the extraordinary growth of DECUS since its inception in 1961. During the past year, we have more than doubled in growth as well as service to the users.

Below are listed the statistics showing DECUS activity for 1967 along with a comparison to 1966. Following these statistics is a report by 1967's DECUS President, John Goodenough, which outlines what has been happening in DECUS during the past year.

DECUS Statistics for Year 1967

<u>MEMBERSHIP</u>	<u>1967</u>	<u>1966</u>
New Applications	1189	424
Total Membership (Removed 31 in 1967)	2008	850
Delegates	925	385
Individuals	1049	465
Module Users (64)	34 (not already members)	
Non-Members	480	160
Total on mailing list	2488	1010

DECUSCOPE

Circulation	2775	1975
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PROGRAM LIBRARY

Number of programs submitted (104 accepted, 23 in process)	127	58
Total number of programs in library	294	198
Number obsoleted	8	none
Number of requests completed	950	---
Number of programs issued to requestors	4655	1692
Number of tapes involved in requests	8815	3460
Paper Tapes	8690	
DECtapes	124	
Number of tapes reproduced (verified)	9300 (approx.)	

PERCENTAGE OF INCREASES

- 135% Increase in membership growth
- 146% Increase in number on mailing list
- 125% Increase in size of DECUSCOPE (minus insert section)
- 40% Increase in DECUSCOPE circulation (affected by re-vising mailing procedure)
- 102% Increase in number of programs issued
- 175% Increase in number of programs issued
- 170% Increase in tape reproduction

The attached report of the DECUS Executive Secretary presents a statistical summary of DECUS activities during 1967. The purpose of the present report is to interpret these statistics and assess the events that affected DECUS's operations during the past year.

The single most important development in DECUS is the tremendous growth in membership--DECUS now has more than twice as many members as it had at the end of 1966. This growth has had important effects on our three primary activities: (1) the holding of technical symposia; (2) the distribution of computer programs; and (3) the distribution of information by means of DECUSCOPE, the DECUS newsletter.

Meetings

Our larger membership is reflected by the increasingly professional quality of the semi-annual DECUS meetings. The Spring and Fall DECUS Symposia were attended by 200 persons--the largest attendance yet for a DECUS meeting; and at the Fall meeting, over thirty technical papers were presented, more than ever before. The increasing technical depth in DECUS means that meetings can be organized with parallel sessions devoted to relatively narrow technical areas. The Spring Meeting in 1968 will be the first to fully take advantage of DECUS's greater technical depth.

A larger membership is also evidenced by the interest in regional and special purpose meetings. During 1967, a special one-day Biomedical Symposium was held in New York, a meeting of Canadian members was held in Canada, a meeting of European users was held in England, and a Module Users Group was organized within DECUS.

To meet the potential needs and problems posed by these and future special interest groups, the DECUS Constitution was amended in 1967 to provide for a special form of organization within DECUS--the Special User Group (SUG). Each SUG will have its own Chairman and may organize its own meetings or technical sessions with the aid and support of DECUS. The DECUS European Committee is the first DECUS Special User Group.

Proliferation of meetings imposes a severe burden on the DECUS staff and detracts from the importance and quality of the semi-annual general DECUS meetings. The DECUS Board has informally adapted the policy of discouraging meetings that are separate from the Spring and Fall DECUS Symposia. Instead, groups with special interests will be requested to organize special sessions at one of our semi-annual meetings. We feel that this policy will increase the quality and interest of the DECUS meetings, decrease the burden on the DECUS staff, and better serve the needs of all DECUS members.

Financial

DECUS derives income from the holding of its technical symposia. Our meetings are budgeted to cover expenses without making a profit, but surplus from any meeting is added to the treasury to cover any deficit that might occur in future meetings. It was decided this year that the primary purpose of the DECUS

treasury is to provide a hedge against unexpected costs at future meetings. In particular, it was decided that funds from the treasury could not be used to defray travel expenses of any elected member of the DECUS Board who is traveling on DECUS business.

Since most of the DECUS operating expenses are covered by the DECUS-DEC Support Agreement, DECUS has no need and no intention of building up a large treasury.

Program Library

The increase in membership and the addition of new computers to the DEC product line resulted in an explosive growth in the number of programs distributed by DECUS. Approximately 9,300 program tapes were duplicated (and verified), filling approximately 950 requests for programs. The DECUS program library is clearly in active use by the membership.

The tremendous number of tapes distributed placed extreme demands on the facilities and procedures for duplicating tapes. Present procedures allow for a two to three week delay in filling a request, but problems can be anticipated in 1968 when present duplicating facilities become saturated.

DECUSCOPE

The monthly DECUS newsletter has grown in size, primarily because of the distribution of DEC Program Maintenance notices within DECUSCOPE and because of the inclusion of letters from members. Both kinds of information are felt to be a significant addition, increasing the usefulness of DECUSCOPE to members. Offsetting the increase in size, the DECUSCOPE mailing list and mailing procedure was revised to insure that copies were not distributed unnecessarily.

DECUS-DEC Support Agreement

The activity in the program library and the large attendance at technical symposia show that DECUS is meeting important needs of its members. Our ability to meet these needs is predicated on the support DEC gives DECUS as described in the DECUS-DEC Support Agreement. 1967 marked the first full year of operation under this agreement, and the agreement has proven useful and workable.

Commendation

The DECUS Executive Secretary is provided under the Support Agreement, and the DECUS Board is particularly appreciative of the initiative and good judgment exercised by Mrs. Angela Cossette in carrying out her responsibilities.

FALL 1967 SYMPOSIUM PROCEEDINGS

The proceedings of the Fall Symposium held in Anaheim, California on November 10 and 11 are now available. Copies are being mailed to all meeting attendees. Anyone else interested in obtaining a copy should contact the DECUS office.

DECUS CANADIAN SYMPOSIUM

The second DECUS Canadian Symposium was held at the Skyline Hotel in Ottawa on February 23. Below are abstracts of the papers presented. Proceedings of the meeting should be available in April.

SMALL COMPUTER APPLICATIONS IN A POWER SYSTEM

J.D.A. Griffin
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This paper concerns the use of a PDP-8 to investigate possible computer applications in certain areas of power system operation. Study thus far has centered primarily on computer-based relay protection and on computer-controlled displays for control rooms. For the initial investigations, a method of generating CRT displays has been developed which, being both effective and low-cost, may find application elsewhere.

AUTOMATIC PROCESSING OF ABSORPTION SPECTRA

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In the experiment to study the high-altitude atmospheric composition, a large number of absorption spectra are recorded with a FM-FM telemetry system.

Automation of the data processing replaces the use of a planimeter by electronic integrations controlled in width and position by a program. From these integrals, the absorption of a given spectrum band is computed, as well as other experimental parameters such as altitude and temperature.

A computer, the PDP-8/S, and an interface consisting mainly of five counters sum the signal frequencies given by the FM-FM telemetry system with an accuracy of 0.1 cycle and allow more than 500 integrations per second. The counter time base is a reference frequency recorded on the magnetic tape. This automatically compensates for the wow and flutter of the playback recorder.

Finally, the system controls a pen recorder to reproduce at high speed the most interesting parts of the spectrum.

USE OF THE PDP-8/S FOR DATA ACQUISITION AND CONTROL OF THE AERODIST AIRBORNE SURVEY SYSTEM

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Ottawa, Ontario, Canada

The Surveys and Mapping Branch of the Department of Energy, Mines and Resources employs an integrated airborne survey system which permits distance measurement, photo positioning and extension of ground surveys over relatively large distances

to Geodetic precision. The interface between the system-- which includes "Aerodist", a 3-channel microwave distance measuring unit, camera, radar profile recorder and various temperature and pressure measuring devices, and the PDP-8/S-- is described. The processor is also used in the field office for final data reduction by the computing section, giving the unit high utility. Special operational problems encountered in aircraft and field office use and their solutions are illustrated.

PDP-9T: COMPATIBLE TIME SHARING FOR THE REAL-TIME LABORATORY

M. M. Taylor¹, D. M. Forsyth², and L. Seligman³

Modifications have been made to the PDP-9 to permit real-time control of laboratory apparatus in a time-shared environment. The system is designed to accommodate about six independent real-time users, providing each with device service latencies of under 100 microseconds and response latencies of a few milliseconds. At the same time, a similar number of interaction or background jobs may be sustained by this system (e.g., editing assembling FORTRAN jobs). The PDP-9T system provides each user with a virtual memory space of 32K words. Physical core of the PDP-9T may be expanded to 256K words. The virtual user machine looks like an ordinary PDP-9 except that (1) a few instructions trap to the monitor (e.g., HLT, OAS); (2) an IOT instruction is decoded by hardware into 1 of 256 possible calls to the system monitor; and (3) programs written to capitalize on the nature of the environment will run more efficiently than those which pretend to be in an ordinary PDP-9. (This paper was given at the Fall 1967 DECUS Symposium, Anaheim, California.)

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2. Harvard University, Department of Psychology, Cambridge, Massachusetts
3. Digital Equipment Corporation, Maynard, Massachusetts

A SIX-CHANNEL MULTIPLEXER FOR THE PDP-8 DATA BREAK FACILITY

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A six-channel multiplexer for use on the data break facility of the PDP-8 computer is described. It is designated MPX-1 and functions provided are very similar to those available in Multiplexer type DM-01 manufactured by DEC. However, the internal organization of MPX-1 differs significantly. Unlike DM-01 which uses one module per bit for data and data address multiplexing, MPX-1 uses one gate per bit. As a result, modules on the required channels alone need to be plugged in. This results in a more economical and flexible design. Important timing considerations for successful multiplexer operation and how conservative timing margins are achieved in the MPX-1 are described.

A PROGRAM TO SIMULATE NAND LOGIC SYSTEMS

I. A. Davidson
Northern Electric Company Research and Development
Ottawa, Ontario, Canada

A NAND logic system simulator has been written for a PDP-8/S. The network arrangement is described through the Teletype keyboard, the input signals via the switch register while the output levels are typed out. The simulator considers the time taken for disturbances to be propagated through the system until a stable configuration is found.

Various systems have been simulated, including the interface logic for a card reader.

SOME EXPERIENCES IN INTERFACE DESIGN AND FABRICATION

E. J. Gabe and R. H. Goodman
Department of Mines, Energy and Resources
Ottawa, Ontario, Canada

An interface has been built which will allow a 4-Circle X-Ray diffractometer with optical encoders to be run on-line with a PDP-8. Some considerations, which now seem obvious, came to light only gradually during the course of the work. These include: devoting considerable time to the planning stage of the work to try to anticipate all likely needs, weighing the advantages of hardware and software as a means of implementing each part of the interface, and in the case of a complex interface, balancing the cost of hardware against purchasing additional computing power. Examples to illustrate these points will be given and our present views on a reasonable hardware/software balance.

USE OF ITERATIVE PROCESSES IN EVALUATION OF STRESSES IN STATICALLY INDETERMINATE SYSTEMS OF ELASTIC BARS

Dr. Adolph Feingold and Herbert R. Alcorn
University of Ottawa
Ottawa, Ontario, Canada

The problem is statically indeterminate and results in a non-linear system of equations which does not admit of a closed-form solution. The object of this paper is to present an iterative process suitable for computer application which may also be conveniently used in solving other similar problems.

A REMOTE INTERFACE FOR A PDP-8

Pierre Goyette
University of Ottawa
Ottawa, Ontario, Canada

This paper discusses the design and construction of an interface that allows the computer to be used at a remote location joined to the computer by a two-way communications link. The remote interface allows for 16 I/O channels and accommodates an interrupt-like action. The communications hardware was built using integrated circuits with a floating common to achieve a match between the two sets of logic levels. Trans-

mission rates can be varied. Since one of the prime requirements was programming ease, the design chosen was far from the simplest in terms of hardware.

ON-LINE PSYCHOACOUSTIC EXPERIMENTATION WITH A MINIMAL PDP-8/S

C. Douglas Creelman
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Toronto, Ontario, Canada

An interpreter and operating system has been designed to run observers in auditory signal detection and recognition experiments with a wide range of experimental designs possible. Control of durations of events is critical, and sets of "simultaneous" events must be capable of being chosen. Duration control is through a hardware clock which drives a counter set under program control. The clock is connected to the program interrupt. The program uses the time the clock is counting to place a subsequent set of IOT instructions immediately below location 0 so the occurrence of an interrupt is followed as closely in time as possible by a new set of events. Included in the system is facility to use PEST (Parameter Estimation by Sequential Testing) to set stimulus parameters as a function of recent observer responses; a procedure which reduces experimental time considerably.

THE WESTERN MULTI-COMPUTER SYSTEM

George Lake
University of Western Ontario
London, Ontario, Canada

The paper describes a combined remote access batch processing system involving two computers directly coupled. The system exploits the advantages of both machines.

PDP-9 OPERATING SYSTEM WORKSHOP

James Murphy, Chairman
Digital Equipment Corporation
Maynard, Massachusetts

This lecture and informal discussion period is directed towards the design philosophy of the PDP-9 ADVANCED SOFTWARE Operating System which centers on user convenience and optimum core utilization.

The subtopics will be:

1. The comprehensive, device independent, input/output programming system which includes handlers for all the standard peripheral devices.
2. The expansion and specialization capabilities of the system to utilize all central processor and standard or non-standard peripheral options.
3. The keyboard control for automatic storage, retrieval, loading and execution of all system and user programs.
4. Complete error analysis at monitor, input/output and system program levels.

PDP-8 (DISC) OPERATING SYSTEM WORKSHOP

Roger Pyle, Chairman
Digital Equipment Corporation
Maynard, Massachusetts

This lecture and discussion session is devoted to a presentation of the design philosophy of the PDP-8 Disc software. The primary features exhibited are ease of use, increased thru-put and user liberation from operator panel switch dependency.

The following topics will be discussed:

1. The philosophy behind the monitor development and the benefits to the user.
2. The user monitor commands and internal structure of the monitor, including the core requirements, limitations, extensions, and I/O device handling.
3. The standard system programs attached to the disc system, both for 4K memory and extended memory. A complete discussion will be given describing the way programs are saved on the disc, the general usage of the disc as a program storage and data file storage device.

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PROGRAMMING NOTES

TEXT FACILITY FOR USE WITH THE PDP-8

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Frequently it is required to generate printed text in the course of executing a program. By far, the most convenient way of doing this is to use the MACRO-8 text facility to introduce messages into an ASCII program and to use a somewhat modified version of the Alphanumeric Message Typeout program (Digital-8-18-U) to cause the message to be printed out when the program is executed.

An ASCII listing of this modified program can be found at the end of this article. It uses addresses 4400 to 4457 inclusive, selected so that it can be used in conjunction with any one of the four parts of the Floating Point Arithmetic Package (Digital-8-5-S). It also uses the auto-index register 0017, which must be available whenever the program is called. In addition, one other Page 0 address must be used to enter the program indirectly (exactly the same way as the Floating Point Packages are entered). It is often convenient to use address 0004 for this purpose, although this precludes the use of DDT-8 for debugging. This program must be compiled by the use of MACRO-8, and the resulting BIN tape is stored for subsequent use.

Examples

The use of the text facility can best be shown by examples.

The program to type out THE CAT SAT ON THE MAT would read as follows in ASCII:

```
*0004
MESSAGE, 4400

*0200
START, KCC
    TLS
    JMS I MESSAGE
TEXT !THE CAT SAT ON THE MAT!
    HLT
$
```

MACRO-8 will compile this program by storing the text in stripped ASCII characters, packed two characters per address, and ending with 00 as a terminating signal. (This will put HLT at address 0217 in the example given.)

The resulting BIN program is loaded, followed by the BIN tape of the modified Digital-8-18-U program. The program is started at 0200 when the desired message will be typed out.

The following points should be noted:

1. The print routine used by Digital-8-18-U must be initialized by TLS (NOT by TCF), just as the Floating Point Package routine must be initialized. Accordingly, neither routine can be readily used in conjunction with the Interrupt facility.

2. The exact format must be followed; the pseudo-instruction TEXT must be followed by a space, a delimiting character (! in the example given), the text itself, and a repetition of the delimiting character.

3. There is no provision for storing CR or LF in this system. If either of these is required, they may be generated in the final text print-out by using % to give a CR and # to give a LF. No CR or LF will be executed in the ASCII listing by these characters; the punch should be turned off, CR and LF operated as required, and the punch turned on again to produce CR and LF in the ASCII text. For example, to produce in the final text:

```
THE CAT SAT
ON THE MAT
```

the program given above will be modified as

```
*0004
MESSAGE, 4400

*0200
START, KCC
    TLS
    JMS I MESSAGE
    ! THE CAT SAT%#
    ON THE MAT!
    HLT
$
```

Following %#, the punch is turned off, CR and LF pressed, and the punch turned on again.

The characters represented by the ASCII codes listed below cannot be handled by this program.

ASCII Code	Character
300	@
377	RUB OUT
207	BELL
243	#
245	%

/TEXT FACILITY (8-18-U MODIFIED)

```
*4400
MESS, 0
    CLA CMA
    TAD MESS
    DCA 0017
    TAD I 0017
    DCA MSRGT
    TAD MSRGT
    RTR
    RTR
    RTR
    JMS TYPECH
    TAD MSRGT
    JMS TYPECH
    JMP MESS+4
MSRGT, 0
```

(continued)


```

TYPECH.,  Ø
          AND MASK77
          SNA
          JMP I ØØ17
          TAD M4Ø
          SMA
          JMP .+3
          TAD C34Ø
          JMP MTP
          TAD M3
          SZA
          JMP .+3
          TAD C212
          JMP MTP
          TAD M2
          SZA
          JMP .+3
          TAD C215
          JMP MTP
          TAD C245
MTP,      TSF
          JMP .-1
          TLS
          CLA
          JMP I TYPECH
MASK77,   ØØ77
M4Ø,      774Ø
C34Ø,     Ø34Ø
M3,       7775
C212,     Ø212
M2,       7776
C215,     Ø215
C245,     Ø245
§

```

(type R123 or similar). The first method requires one module per address bit, whereas the second method requires one gate per bit. If cost of the modules were the only deciding factor, the relative merits of these two methods can be worked out assuming the required number of channels is known. For example, if only three channels are needed, the second method is obviously preferred because it costs only \$114 for 12 bits against \$156 for the first.

Figure 2 shows another possible method. This is simpler and cheaper than the two previously mentioned. In this method the address bit buses are connected to the unit address lines through isolating diodes. If a bit is 0 to establish the correct address code, the diode in that position is disconnected. For example, if the address code for Unit 1 is (7754)₈, then diodes from bit 10 and 11 buses to the Unit 1 address line will be missing.

When Unit 1 is selected, Unit 1 address line is driven to ground and all other unit address lines will be at -3 volts. The diodes associated with Unit 1 can now conduct and drive the corresponding buses to ground. Diodes associated with the other units, however, remain cut off and, hence, have no effect on the buses. The effect of this arrangement is that the contribution to the address buses will be only from the selected address line, and the bus on which there is no diode will remain floating.

The address buses are connected to the level inputs of the DCD gates on the set side of the MA register in the PDP-8. When these DCD gates are strobed during the CA cycle, any bit whose bus was left floating will be transferred as a "0" into the MA. From the arrangement shown in Figure 2, it is easy to verify the validity of the following table.

MULTIPLEXING OF DATA ADDRESS BITS FOR PDP-8 3-CYCLE DATA BREAK FACILITY

R. Krishna
University of Saskatchewan
Saskatoon, Saskatchewan, Canada

High-speed transfers can conveniently be handled by using the data break facility of the PDP-8. Most of the high-speed peripherals use the 3-cycle data break. However, as the PDP-8 has only one channel available for data break transfers, it becomes necessary to use a multiplexer if more than one device has to be connected to the break channel.

The multiplexer can be thought of as a collection of high-speed switches connecting the information lines from the peripheral devices to the computer in a predetermined order. The multiplexer is also capable of distributing the signals from the computer to the peripherals. All necessary signals for a successful data break operation are listed in the Small Computer Handbook. Because (during a data break) peripherals can communicate directly with the core, the address for the location of current interest must be specified by the device. For a 3-cycle data break, this address is fixed on one address per device basis and, hence, can be specified by proper wiring. If a device is requesting access for a transfer, multiplexer presents the corresponding address only to the computer lines.

Two possible methods of multiplexing the address bits are shown in Figure 1. The first method uses And/Nor gate (type R141 or similar) modules and the second method uses diode gates

<u>UNIT SELECTED</u>	<u>ADDRESS SET UP</u>
1	(7754) ₈
2	(0032) ₈
3	(0034) ₈
4	(0036) ₈
5	(0070) ₈

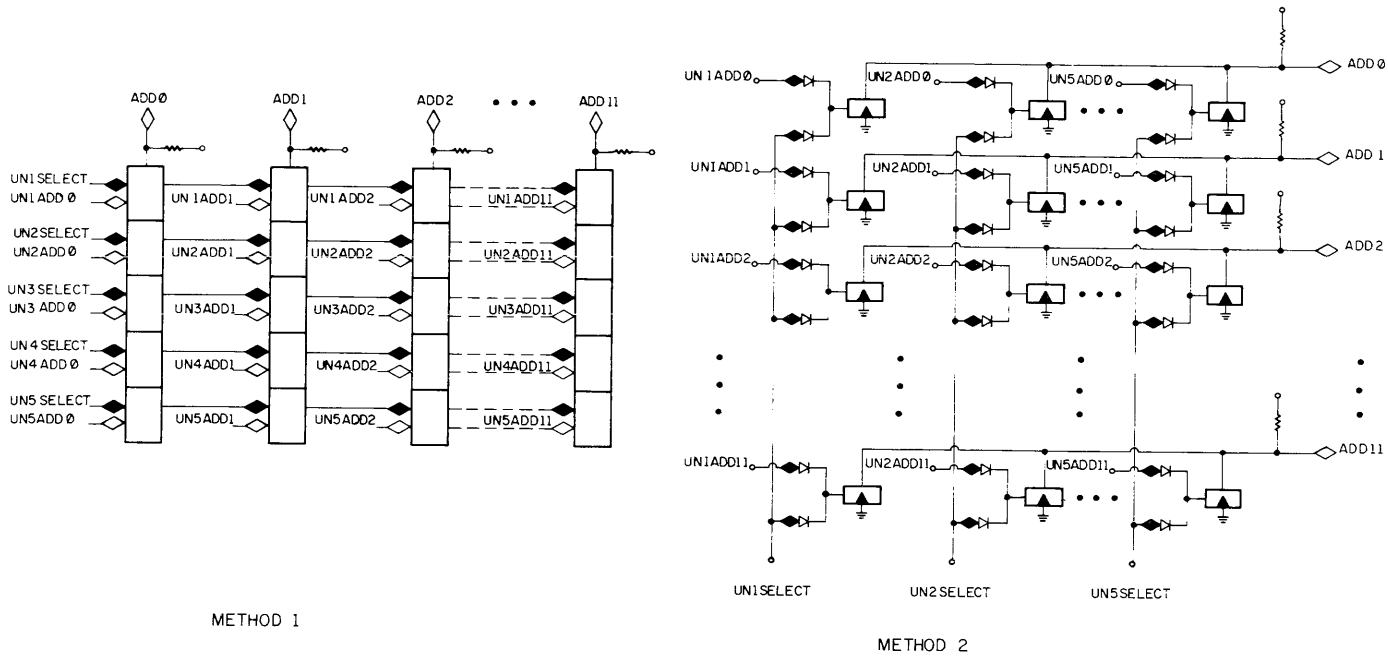


Figure 1.

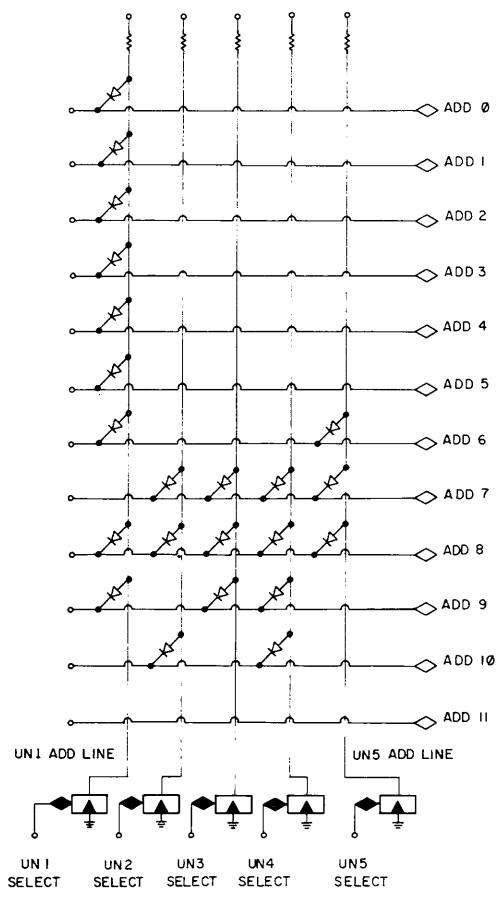


Figure 2.

PUNCHING BINARY TAPES ON THE LINC-8

L. N. Law
 Department of Psychology
 Institute of Psychiatry
 London, England

A problem occurs when attempting to punch a binary tape on the LINC-8 since all zero characters are omitted. This is due to the PROGOFOP subroutine, TYPEIT, which uses the value of the output character as a flag to indicate that the Teletype is busy, and zero flag to indicate that the Teletype is free. Thus, the next character in a string is loaded immediately on top of any zero.

A solution is to use 7777 as a "busy" flag, independent of the character value. A modified TYPEIT, which uses three fewer locations, is as follows:

```

PRINT = 21

*1501

1501 0000 TYPEIT, 0
1502 2021      ISZ PRINT
1503 5306      JMP OKPRINT
1504 6041 WAIT, TSF
1505 5304      JMP .-1
1506 6046 OKPRINT, TLS
1507 7240      STA
1510 3021      DCA PRINT
1511 5701      JMP I TYPEIT
1512 0000      0          /THREE
1513 0000      0          /SPARE
1514 0000      0          /LOCATIONS
    
```

WANTED

I am interested in programs for man-machine "conversation" via the teletypewriter, in English-like sentences, for experiments in computer-aided behavioral therapy (like Colby's, Weizenbaum's, etc.), for information retrieval and library searching (like M. M. Kessler's, Bobrow's, etc.), and for simulation of models of inductive inference and cognition (like the work of Feigenbaum, Mursky, etc.). We have a PDP-8 connected as a satellite to the University's 360/67 via a 220 cps line. We also have a SOROBAN high-speed card reader, high-speed paper-tape reader, high-speed tape punch, and an I/O analog converter attached. I would also like to know about programs now under development or in planning in this connection.

I am also interested in any programs which store psychological or educational tests, accept on-line responses from subjects, and score these.

Manfred Kochen
 Associate Professor
 The University of Michigan
 Mental Health Research Institute
 Ann Arbor, Michigan 48104

As part of our work on the PDP-8, we want to solve a set of differential equations. In order to solve these we need an

integration routine (Runge-Kutta) or something similar.

Information on routines of this type which are available would be appreciated.

H. Kyle Collins, Jr.
 Department 72-15, Zone 12
 Lockheed-Georgia Company
 Marietta, Georgia 30060

LETTERS

"Dear Mrs. Cossette:

"The letter from Omega-t Systems Incorporated requesting information about a digital analog simulator for the PDP-8 was of considerable interest to us.

"Dr. T. G. Coleman and I recently developed such a simulator for another small computer, the IBM 1401, and plan to use the same techniques to fit the simulator into the PDP-8 and PDP-9. The system is known as PAS(150) for the Physiological Analog Simulator and currently will handle up to 150 analog blocks.

"Enclosed are copies of two reprints describing the system. We expect a more detailed article to appear in a future issue of Computers and Biomedical Research.

"We would like to know of any other persons interested in such an analog simulator as well as any group who might like to provide some research support to further develop the system for conversational mode operation.

Cordially,

Fred R. Sias, Jr.
 Research Instructor
 The University of Mississippi Medical Center
 Jackson, Mississippi 39216"

"Dear Mrs. Cossette:

"The Gorman-Wolfberg technique for clearing all of memory in the PDP-8 (DECUS 5/8-27a), including the eight-instruction program itself, can be slightly improved in efficiency by the following minor alterations:

Absolute Clear

<u>Location</u>	<u>Octal</u>	<u>Symbolic</u>
0000	3000	3000
2772	7410	SKP
2773	3376	DCA .+3
2774	2000	ISZ 0 /START, AC=0
2775	3400	DCA I 0
2776	5372	JMP .-4
2777	3374	DCA .-3
3000	3400	DCA I 0

"This reduces the execution time by about 10%, at no additional cost in program space. Even this record can be beaten,

however, by a basically different technique for absolute clear, which also requires only eight instructions, all conveniently contiguous, and which is more than twice as fast:

<u>Absolute Clear</u>		
<u>Location</u>	<u>Octal</u>	<u>Symbolic</u>
7771	3776	DCA I .+5 /START, AC=Ø
7772	2011	ISZ 11
7773	2376	ISZ .+3
7774	5371	JMP .-3
7775	3374	DCA .-1
7776	ØØØ1	ØØØ1
7777	4411	JMS I 11
ØØØØ	3411	DCA I 11

Absolute Halt (Assumes locations ØØ13 through 7374 clear.)

<u>Location</u>	<u>Octal</u>	<u>Symbolic</u>
ØØ1Ø	767Ø	767Ø
ØØ11	ØØ11	ØØ11
7375	341Ø	DCA I 1Ø
7376	1ØØØ	TAD Ø
7377	3411	DCA I 11
74ØØ	1ØØØ	TAD Ø /START, AC=Ø
74Ø1	4411	JMS I 11
74Ø2	3411	DCA I 11
ØØØØ	74Ø2	HLT

Frederick R. Kling, Research Psychologist
Educational Testing Service
Princeton, New Jersey 08540

"Since it is puzzling just why anyone would want to clear all of memory, it might serve a useful purpose for readers to share their reasons for deliberately wiping out RIM, etc. Our particular reasons all stem from a problem we were having a few weeks back with the night watchman. It seems that he had discovered how to enliven his nightly rounds by turning on the PDP-8, pressing random control keys, and communing in some private, esoteric manner with the blinking lights. Inevitably, he managed to bomb RIM and everything else. When both polite and nasty notes had failed to deter him, we resorted to an absolute memory clear in hopes that the resulting dull, unchanging panel countenance would strike him as non-communicative, thus terminating the nightly dialogues.

"For several nights all went well. Each morning we found memory entirely blank, just as we had left it. One memorable morning, however, we discovered the following: Switch register set at 2000, hash all through memory, and "COGITO ERG" typed neatly on the teletype which was still switched on line. Our best efforts at reconstruction suggest that our watchman started the computer with memory all clear, raised bit one in the switch register as the computer cycled through core, and then pressed stop, deposit, and continue in that order--probably only once, though we cannot be certain. We suspect he had a joyful reunion with the blinking panel lights but turned the computer off in panic when it commenced typing out its precious message.

"What was the random address where he deposited ISZ Ø? Did he deposit it more than once? And, if so, after how long an interval? Was the computer about to concur with Descartes' famous dictum? Or was it about to reach some more astounding conclusion?

"We may never know--our watchman has vanished, leaving no trace. Since then, we have spent many long hours clearing memory and randomly inputting a single bit one (ISZ Ø), producing magnificent panel displays for up to twenty minutes and more but nary a peep from the teletype. (Input locations 2ØØ and 2Ø1 are excellent examples.) Recently we have begun randomly inputting a second bit one after the panel lights have stabilized. One Bit One and Two Bit One Artificial Intelligence Tests we call these experiments, and we earnestly solicit help in conducting them from any and all PDP-8 users interested in recovering the conditions that precipitated that fleeting moment of cosmic significance which our watchman, poor man, was unable to comprehend.

"Oh, yes. One other reason we have found for calling Absolute Clear. It enables us next to call Absolute Halt:

MODULE NEWS

At this writing approximately 65 users have applied for membership in the Module Users Group of DECUS. Below is a list of the areas of application along with types of modules and computers used by these members.

TYPES OF FLIP CHIP MODULES USED

<u>Module Type</u>	<u>% of Applicants</u>
R series	97%
A series	45%
B series	34%
K series	6%
M series	3%

TYPES OF DEC COMPUTERS USED

<u>Word Length</u>	<u>% of Applicants</u>
12 bits	63%
18 bits	44%
36 bits	6%

COMPUTER INTERFACES AND PERIPHERALS

Type of Application

A-D and/or D-A
Magnetic Tape
'Scope Display
Real Time Clock
Joining two digital computers
Data Acquisition Systems
Plotter
High Speed Data Channel
Multiple Teletypes
Pulse Height Analyzer
X Ray Instrument
Punched Card Equipment

Shaft Encode:
 Drum Memory
 Paper Tape
 Microdensitometer
 Data Transmission
 Joining digital to analog computer
 QRS Flag
 CRAM
 Flame Cutter
 Milling Machine
 Hewlett Packard Counter
 SMP (Scanning-Measuring Projector)
 Brain Scanner
 Stepping Motor
 WANG LOCI - 2
 Measuring Machine

 Ultrasonic Flaw Detector
 AMP Credit Card Reader
 Teaching Machine
 Electrochemical Control
 VIDICON Input
 Communications Terminal
 Auto Call Unit
 Tactile Perception Unit
 Data Set
 Process Control
 Production Machinery
 Disc Memory
 Core Memory

STAND ALONE SYSTEMS

Type of Applications

Computer, Special Design
 Signal Generator
 Analog Multiplexer
 Sample and Hold
 Clock
 Noise Generator
 Animal Behavior Tester
 Integrated Circuit Tester
 Television Encoder
 Time Code Generator for 16 mm film
 FM Receiver to Mag Tape Interface
 Binary-Decimal Converter
 PCM Simulator & Decoder
 Radar Range Error Detector
 Controls for Automatic Machinery
 Analog Data to Punched Tape Converter

MODULE USERS - SEND IN YOUR MODULE APPLICATION NOTES FOR PUBLICATION. MATERIAL SHOULD BE SENT TO: ANGELA COSSETTE, EDITOR, DECUS, MAYNARD, MASS. 01754.

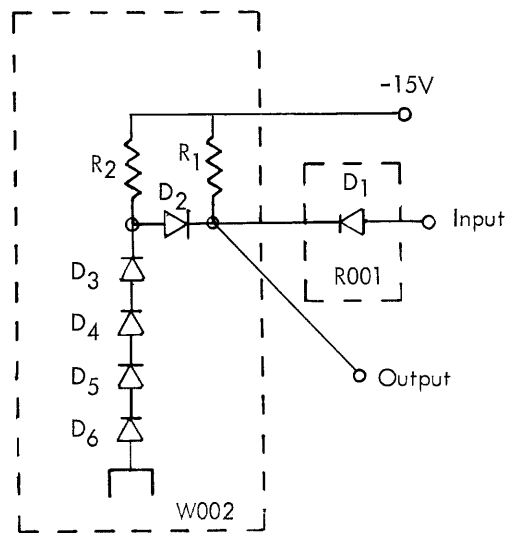
NOTE ON NEGATIVE INPUT LEVEL CONVERSION

R. Krishna
 Department of Electrical Engineering
 University of Saskatchewan
 Saskatoon, Saskatchewan, Canada

It is not uncommon for DEC Computer users to interface equipment with logic voltage levels other than -3 and 0 volts. When it is a matter of converting higher negative voltages to DEC Levels, it is logical and customary to use Negative Input Converter W511 modules. Recently, we looked into methods of gating thirty-eight -6V level signals into the PDP-8 accumulator. This, of course, could have been done with 19 W511 modules for level conversion followed by 38 inverters before gating with R123 modules into accumulator. The cost of 19 W511 modules alone would have been about \$325 not ignoring the fact that they occupy 19 slots on the mounting panel. This seemed out of proportion to the 7 R123 modules which actually perform the gating, at a cost of \$140. In addition, use of W511 modules for level conversion makes it necessary to include 6 R107 modules at \$150 to restore the correct polarity. All this amounts to about \$475 extra as a penalty. This convinced us to seek some other method of level conversion which would be more compact and economical. The possibility occurred to us to use W002 and R001 modules to achieve the level conversion without inversion. The working principle of the proposed method is very simple, as explained with the aid of the diagram given below.

Forward conduction of silicon diodes D_3 through D_6 provide the -3V logic supply. If the input is at -6V, diode D_1 is reverse biased and the output will be at -3V because D_2 can conduct through R_1 . When the input is at ground potential, the output also tends to assume ground potential because D_1 can now conduct through R_1 . Under these conditions, diode D_2 is reverse biased.

This method of level conversion seems attractive, as long as one is aware that load current flows through D_1 when the input is at ground and will result in a voltage drop across it.



MODULE APPLICATION NOTE

BIOMEDICAL RESPONSE SCHEDULING

Experiments involving the response behavior of animals may be classified broadly as follows:

Fixed Ratio Schedules

In these experiments, the animal is rewarded or "reinforced" only after it has responded a fixed number of times. That is, the ratio between responses and reinforcements is fixed. When the fixed ratio (FR) is 1, the subject is being given "Continuous Reinforcement", but more often the FR is much greater.

Variable Ratio Schedules

In these experiments, the number of responses required for each reinforcement varies in a fixed, sequential order. That is to say, the ratio changes after each response. Typically, the ratio may vary from one to ten during ten sets of responses.

Fixed Interval Schedules

In these experiments, reinforcement does not occur until some time after the last reinforcement regardless of the response activity. In addition, a limit may be imposed on the period during which the subject may be reinforced. This condition is referred to as a Fixed Interval with Limited Hold.

The hardware required to perform such experiments usually consists of a variable-length counter which is initialized by a reinforcement and a delay to control the hold time.

Variable Interval Schedules

In these experiments, the interval during which responses are not reinforced is varied after each reinforcement.

The same complement of DEC Flip-Chip modules can be used to perform each of the above types of experiments. The basic function being performed is the measurement and control of a time interval. Figure 1 is a block diagram of a variable ratio scheduler. Two separate binary counters are used, one to count responses and the other to count reinforcements. The response counter is reset by the output of a digital comparator which compares the two counters. In this way, the number of responses required to produce a reinforcement can be made proportional to the number of reinforcements that have occurred.

Module List

W051	.....	1
W501	.....	1
R603	.....	1
R202	.....	5
R131	.....	1

Spectra Accumulation

The experimenter is sometimes interested in obtaining a histogram of response intervals. This is usually part of still another type of experiment in which reinforcement occurs only when the subject responds at a rate below a specific value, usually expressed in seconds. This is known as Differential Reinforcement of Low Rates (DRL). Typically, up to 20 time intervals are investigated, and up to 100 events are recorded in each time interval. This involves the use of twenty 7-bit counters and twenty delays, plus the associated control circuits. The following is a list of modules required to construct such a 20 channel analyzer:

R202	.....	70
R302	.....	12
W051	.....	1
R602	.....	1

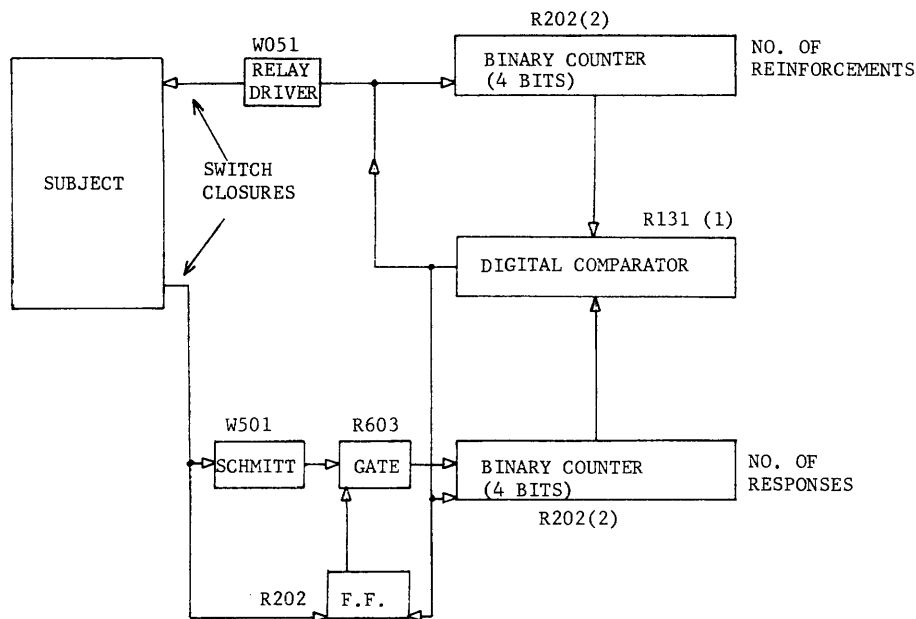


FIG. 1 - VARIABLE RATIO SCHEDULER

NEW DECUS MEMBERS

PDP-1 DELEGATES

Raymond P. Holler
ITEK Corporation

PDP-4 DELEGATES

Timothy C. Rand
University of Michigan

PDP-5 DELEGATES

Jerry D. Ford
Electronic Associates, Inc.

PDP-6 DELEGATES

John J. Kilduff, Jr.
Brookhaven National Laboratory

John B. Locke
Rutgers University

K. Muller
Universitat Bonn
Germany

PDP-7 DELEGATES

A. Bishop
Royal Radar Establishment
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Scotland

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University of Rochester
School of Medicine & Dentistry

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Center

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Siemens America, Inc.

DIGITAL SOFTWARE NEWS

This newsletter is intended for PDP-5/8, 8/S, 7, 9, and LINC-8 users. It is compiled and published by the Software Maintenance Group and contains information about the following.

1. **Software Problems and Corrections:** Various problems with Digital's standard library programs and manuals are discussed and solutions given. In cases where no corrections are available at the time of publication, they will be included in a later newsletter.
2. **Programming Notes:** Various programming aids are discussed, generally in response to customer questions. An attempt is made to supplement the manuals where necessary. Suggestions for subject material of these notes should be directed to the Software Maintenance Group (address below).
3. A list and brief description of new and/or revised software which is available from the Program Library.

The Software Maintenance Group is responsible for the maintenance of Digital's standard library programs. There is a software support person at most of the regional and district sales offices and initial reports should be made to them. In cases where they are unavailable, reports should be directed to:

Software Maintenance Group
Digital Equipment Corporation
146 Main Street
Building 12 Second Floor
Maynard, Massachusetts

It is strongly suggested that all problems referred to this group be

sent on Software Trouble Report Forms, which are available from the Program Library (address below). For more efficient service, the following information should be included.

1. Type and configuration of machine.
2. Brief but concise description of the problem. Include the name and date of the Digital library program in use at the time of problem.
3. Listing of user program in use at time of problem.
4. Listing of erroneous results and/or error messages.
5. Contents of AC and PC where applicable.

New and revised software, manuals, and Software Trouble Report forms are available from the Program Library. When ordering, include the document number and a brief description of the program or manual desired. At this time there is no automatic updating of revised programs and manuals. They will be shipped only on request. Revisions and notifications of updates will be published in this newsletter, which will continue to be part of DECUSCOPE. Direct all inquiries and requests to:

Program Library
Digital Equipment Corporation
146 Main Street
Building 12 First Floor
Maynard, Massachusetts 01754

I. PDP-5, 8, 8/S

A. PROGRAMMING PROBLEMS

PROGRAM: PDP-8 DISC SYSTEM BUILDER (DEC-08-SBAB)

PROBLEM: An error has been found in the DISC Monitor Builder. This affects only those systems equipped with more than one disc (i.e., one DF32 and one, two, or three DS32s) and will cause failure in such systems.

SOLUTION: This error can be corrected by changing five locations in core before building the Monitor on the DISC.

The locations to change are underlined below. The other instructions are given only as reference points and should remain as they are.

On page 1, section 3, of the System Builder writeup (DEC-08-SBAB) there are instructions for building a monitor. After completing step c (Load BUILD using Binary Loader), make the changes indicated below. When the five locations have been changed and checked continue with step d in the writeup.

CURRENT CONTENTS:

0306	1022	DBLK1	/SET INDICATOR TO ADJUST FINAL BLOCK OF SAM STRING TO
0307	2731	ISZ I SMFIX	/GIVE "SCRATCH AREA"
0310	4450	JMS I DIOX	/WRITE THE "SAM" BLOCKS ONTO THE DISC.
:			
:			
0333	0514	BLOCF, BLOC	} PREVIOUSLY UNUSED BY MONITOR
0334			
0335			
0336			
0337			

CHANGE TO:

0306	1022	DBLK1	
<u>0307</u>	<u>5334</u>	JMP 0334	
0310	4450	JMS I DIOX	/WRITE THE "SAM" BLOCKS ONTO THE DISC.
⋮			
0333	0514	BLOCF, BLOCK	
<u>0334</u>	<u>2731</u>	ISZ I SMFIX	
<u>0335</u>	<u>7124</u>	STL RTL	
<u>0336</u>	<u>3555</u>	DCA I ONEU3	
<u>0337</u>	<u>5310</u>	JMP 310	

B. PROGRAMMING NOTES

1. The following is a modified RIM Loader which will use the high speed reader to load the Binary Loader and other RIM format tapes. The starting address is 7756, as in the low speed version.

ABS. ADDR.	OCTAL CONTENTS		SYMBOLIC	
7756	6014	BEG,	RFC	/clear flag and fetch char. into buffer
7757	6011		RSF	/skip when flag=1
7760	5357		JMP .-1	
7761	6016		RRB RFC	/read buffer into AC, get next char. into buffer
7762	7106		CLL RTL	/rotate channel 8 into
7763	7006		RTL	/AC bit 0
7764	7510		SPA	/is it leader
7765	5374		JMP TEMP-2	/yes clear AC
7766	7006		RTL	/NO rotate channel 7 to LINK
7767	6001		RSF	
7770	5367		JMP .-1	
7771	6016		RRB RFC	
7772	7420		SNL	/link set=origin
7773	3776		DCA I TEMP	/store data
7774	3376		DCA TEMP	/store address
7775	5357		JMP BEG+1	/next word
7776	0000	TEMP,	0	/temporary storage
7777	5301		0	/JMP to start of BIN loader

2. The following is a collection of execution timings of Math Routines for the PDP-8 and PDP-8/S.

Single Precision Square Root Subroutine - DEC-08-FMAA

Execution Time - Timing Equation - If the answer is N, the time for the subroutine is (30 N(25.5)) μ sec.

Single Precision Signed Multiply Subroutine - DEC-08-FMBA

Execution Time - Without EAE

Minimum - When the subroutine discovers that the multiplier is 0, it bypasses the multiplication loop. In this case, execution time is 25.5 μ sec if the multiplier is positive, and 27.0 μ sec if the multiplier is negative.

Maximum - Maximum execution time occurs when the sign of the product is negative and the multiplier consists (in binary) of all 1's. This time is approximately 350 μ sec.

Execution Time - With EAE

Minimum - When the subroutine discovers that the multiplier is 0, the multiplication is bypassed and execution time is 9 μ sec. Also, when the subroutine discovers that the multi-

plicand is 0, the multiplication is bypassed. In this case, execution time will be 22.5 μ sec if the multiplier is positive, and 24.0 μ sec if the multiplier is negative.

Maximum - Maximum execution time occurs when the sign of the product is negative. This time is approximately 71.0 μ sec.

Average - 66 μ sec

Double Precision Signed Multiply Subroutine - DEC-08-FMDA

Execution Time - Without EAE. As is true for Single Precision Signed Multiply, the execution time for Double Precision is a function of the number of binary 1's in the operands.

Maximum - The maximum execution time is 1.605 msec.

Average - Average time will be around 1.4 msec.

Execution Time - With EAE

Minimum - When both the multiplicand and multiplier are positive; 248.3 μ sec.

Average - 270.0 μ sec

Single Precision Signed Divide Subroutine - DEC-08-FMCA

Execution Time - Without EAE

Minimum - 58.5 μ sec (Divide check).

Maximum - 478.5 μ sec.

Average - 460 μ sec. (approximately).

Execution Time - With EAE

Minimum - When the dividend and the divisor are both positive and divide overflow occurs because the high order dividend is greater than or equal to the divisor; 46.5 μ sec.

Maximum - When the dividend is negative, the divisor a positive non-zero number, and no overflow occurs; 106.5 μ sec.

Average - 98.0 μ sec

Double Precision Signed Divide Subroutine - DEC-08-FMEA

Execution Time

Minimum - 1.424 msec.

Maximum - 1.705 msec.

Average - 1.650 msec.

Double Precision Sine Subroutine - DEC-08-FMFB

Execution Time

Minimum - When the argument is a multiple of; 70 μ sec.

Maximum - Without EAE; 10.6 msec.
With EAE; 2.78 msec.

Average - Without EAE; 10.4 msec.
With EAE; 2.6 msec.

Double Precision Cosine Subroutine - DEC-08-FMGB

Execution Time - Calls Double Precision Sine, therefore, in general Double Precision Cosine averages from 75 μ sec to 93 μ sec longer than Double Precision Sine.

Minimum - Occurs when the argument is 0. In this case, execution time is 55.5 μ sec.

Four Word Floating Point Package - DEC-08-FMHA

Execution Times - Without EAE. Execution times are very difficult to estimate as they greatly depend upon the data on which the Floating Point package is operating. Generally, average times are as follows:

- FADD - 382 μ sec + 42(N) where N is the number of shifts needed to align the binary points.
- FSUB - FADD time + 42 μ sec.
- FMPY = Approximately 3.3 msec.
- FDIV - Approximately 3.4 msec.
- FGET - 156 μ sec.
- FPUT - 172 μ sec.
- FNOR - 168 + N(42) μ sec where N is the number of shifts; +84 μ sec if the argument is less than zero.
- FEXT - 140.5 μ sec.

Average - With EAE. The EAE floating-point multiply is at least 1100 μ sec faster than the non-EAE version. The EAE floating-point divide is at least 1165 μ sec faster than the non-EAE version. The Normalize routine, used by all arithmetic routines, may be summarized:

Number of Shifts	Non-EAE (μ sec)	EAE (μ sec)
0	45.0	51.0
1	78.0	83.5
2	111.0	84.5
12	445.5	75.0
24	844.5	121.5
34	1174.5	131.5

The alignment subroutine (add and subtract) may be summarized:

Number of Shifts	Non-EAE (μ sec)	EAE (μ sec)
1	38.2	82.0
2	78.0	83.0
3	17.2	84.0
12	475.2	93.0
24	952.5	91.5

Logical Subroutines (Inclusive & Exclusive OR) - DEC-08-FMIA

Execution Times - Inclusive OR requires precisely 32.0 μ sec. Exclusive OR requires exactly 46.0 μ sec.

Arithmetic Shift Subroutines (Single & Double Precision) - DEC-08-FMJA

Execution Times - Time needed for a given shift may be calculated from the following equations.

Single Precision Shift Left	22.4 + 6.4 N μ sec.
Single Precision Shift Right	For Positive data 22.4 + 9.6 N μ sec.
Single Precision Shift Right	For Negative data 22.4 + 11.2 N μ sec.
Double Precision Shift Left	40.0 + 20.8 N μ sec.
Double Precision Shift Right	For Positive data 40.0 + 24.0 N μ sec.
Double Precision Shift Right	For Negative data 40.0 + 25.6 N μ sec.

Logical Shift Subroutines (Single & Double Precision) - DEC-08-FMKA

Execution Times - Time needed for a given shift may be calculated from the following equations.

Single Precision Logical Shift Right	22.4 + 6.4 N μ sec.
Double Precision Logical Shift Right	36.8 + 24.0 N μ sec.

C. NEW & REVISED PROGRAMS & MANUALS

1. NEW

PROGRAM: PDP-8 DISC SYSTEM EDITOR (DEC-08-ESAA)

The PDP-8 Editor (DEC-08-ESAB) has been modified to operate in a disc environment. The functions are essentially the same as in the paper tape version with some changes to the command set. The disc version of the Editor is available from the Program Library under the following code numbers:

- Document - DEC-08-ESAA-D
- Binary tape - DEC-08-ESAA-PB

PROGRAM: PDP-8 DISC SYSTEM DDT (DEC-08-CDD0)

DDT-8 has been considerably modified to operate in a disc environment. The disc version consists of a resident section containing core swapping and break point logic, plus an essentially invisible portion containing the search, modify, examine and control logic. Disc DDT operates as described in the DDT manual for the paper tape version (Digital-8-4-S) with a few exceptions. It is available from the Program Library under the following code numbers:

- Document - DEC-08-CDD0-D
- Binary tape - DEC-08-CDD0-PB

PROGRAM: PDP-8 DISC SYSTEM PIP (DEC-08-PDAA)

PIP (Peripheral Interchange Program) is a general utility program designed, as the name implies, to transfer files between devices, list directories, and delete unwanted files from either disc or DEC-tape (with the last two features listed above). The preliminary version of PIP is available from the Program Library under the following code numbers:

- Document - DEC-08-PDAA-D
- Binary Tape - DEC-08-PDAA-PB

The above three programs are the descriptive documents and will be supplied free of charge and without request to users who currently have disc systems.

2. REVISED

PROGRAM: ODT-8 DEC-08-COC0

The article describing the rewritten ODT which appeared in the last newsletter (Christmas issue of DECUSCOPE) stated that if the user places a breakpoint on an instruction which references an autoindex register, the autoindex register will not be incremented when the user requests a "continue". The article suggested that the user should increment the appropriate register himself before requesting the continuation of his program.

This latest version, ODT-8, DEC-08-COC0, has rearranged the breakpoint processor to enable it to test for page zero references and execute them as such. In this version it is no longer necessary for the user to increment autoindices, ODT-8 will handle them properly.

This version, as did the previous one, uses essentially the same command set as DDT-8 but without the ALT mode.

ODT-8 is available from the Program Library under the following code numbers:

- ODT (Low core version, origin 1000) DEC-08-COC1-PB;
- ODT (High core version, origin 7000) DEC-08-COC2-PB
- ODT (source) DEC-08-COC0-PA
- ODT (Writeup) DEC-08-COC0-D(L)

3. NEW MAINDECS

MAINDEC-08-D2NA New CR01C Card Reader Test replaces MAINDEC-08-D201

MAINDEC-08-D6GA New A/D "Calibration Check" replaces MAINDEC-845

II. PDP-7/9

A. PDP-7/9 BASIC PROGRAMMING PROBLEMS

PROGRAM: DDT

PROBLEM: After the user types an ' (apostrophe) and before control is transferred to the user's program, DDT issues a line feed to the teleprinter. If the user clears the flag and turns on the interrupt before the teleprinter flag appears, an unwanted interrupt results.

SOLUTION: A modification has been made to DDT which will avoid the problem by waiting for the flag before transferring control to the user program. A new version will be available from the Program Library late in January.

B. PDP-9 ADVANCED SOFTWARE PROGRAMMING PROBLEMS

PROGRAM: SYSTEM GENERATOR (SGEN)

PROBLEM: IOPS 07 is output about 10 minutes into the generation due to incorrect .DAT slot assignments.

SOLUTION: The following .DAT slot assignment must be made correctly:

- 10, -14 to OLD system
- ~~-5~~ to NEW system

Example:

(\$) A DTA0 -10, -14/DTA1 -15

will create a new system on the DECtape on Unit 1 from the existing system on Unit 0.

PROGRAM: FORTRAN IV

PROBLEM: Error messages are not always output with the lines to which they apply.

SOLUTION: The line in error can be either the line printed out with the error message, or the line immediately preceding it.

PROGRAM: FORTRAN IV (DECtape version dated 11/14/67)

PROBLEM: The call statement processor does not work correctly in 16K, 24K and 32K machines.

SOLUTION: Using SYSTEM, make the following patches.

1. Mount the system DECtape on Unit 0, WRITE LOCK.
2. Load SYSTEM at 17720
3. When the computer halts, set AC switch 0=0, type F and depress CONTINUE.
4. When the computer halts, make the following patch, being careful to note core size involved.

Core Size	Address Switches	AC Switches
16K	11141	025420
24K	11141	045420
32K	11141	065420

5. Set AC switch 0=1, type F and depress CONTINUE. ER will be output to the teleprinter, indicating that SYSTEM is unable to write on Unit 0. Put Unit 0 on WRITE ENABLE. Type F, and depress CONTINUE. When the computer halts, FORTRAN IV has been rewritten on the DECtape.

PROGRAM: FORTRAN IV

PROBLEM: There are several major bugs in the current version of the compiler. They are:

1. Hollerith constants do not work.
2. Unary minus is placed before exponentiation in the hierarchy of events. The use of parenthesis does not always eliminate the error.
3. Statement functions do not work correctly in all cases.
4. Long involved iterations will occasionally give completely erroneous results or loss of accuracy.
5. BACKSPACE, REWIND and ENDFILE do not work.

SOLUTION: A new version of the compiler will be issued in the near future which will eliminate these problems.

PROGRAM: FORTRAN IV and MACRO-9

PROBLEM: The versions of FORTRAN IV and MACRO-9 currently being shipped with PDP-9 systems will not allow DECTape input and output for assemblies or compilations in less than 16K systems.

SOLUTION: Smaller versions of both the Assembler and the Compiler are being prepared and, for your convenience, will be shipped directly to your installation as soon as they become available. This should occur no later than March 15, 1968.

PROGRAM: MACRO-9 (DECTape version dated 11/14/67)

PROBLEM: The pseudo-op .END is occasionally not recognized in programs that contain macro calls which contain no real arguments.

SOLUTION: Using SYSTEM, make the following core patch.

1. Mount the system DECTape on Unit 0, WRITE LOCK.
2. Load SYSTEM at 17720.
3. When the computer halts, set AC switch 0=0, type M and depress CONTINUE.
4. When the computer halts, make the following core patches:

Address Switches	AC Switches
13414	157177
13415	557355
13416	613520

5. Set AC switch 0=1, type M and depress CONTINUE. ER will be output to the teleprinter, indicating that SYSTEM is unable to write on Unit 0. Put Unit 0 on WRITE ENABLE, type M, and depress CONTINUE. When the computer halts, MACRO-9 has been rewritten on the DECTape.

PROGRAM: MACRO-9

PROBLEM: Recursive calls within macro definitions initiate an unending processing of that macro.

SOLUTION: Recursive calls should not be used. (Please reference the macro definition given below as an example.)

When a call for the macro MAC is encountered by the Assembler, it searches memory for the definition to expand the macro. Since there is another call for MAC contained within the definition, the

MACRO Assembler goes back once again to obtain the definition. This process will never cease and for this reason, the usage of the macro MAC, as given below, will not be properly processed.

```
.DEFIN  MAC, TAG1, TAG2, TAG3
LAC TAG1
SAD TAG2
DAC TAG3
MAC TAG1, TAG2, TAG3
.ENDM
```

PROGRAM: MACRO-9 MANUAL DEC-9A-AM9A-D and DEC-9A-AM9B-D.

PROBLEM: An incorrect macro generation is given in Section 3.6.3, page 3-9.

SOLUTION:

```
MAC1 TAG1, TAG2, (400, 777, TAG3
should cause the generation of:
LAC TAG1
TAD TAG2
MAC2 (400, 777
XOR (400
AND (777
DAC TAG3
```

The line MAC2 (400, 777 is missing in the manual.

PROGRAM: CONV (DECTape version dated 11/14/67)

PROBLEM: The 7-to-9 Converter lists only to the teleprinter.

SOLUTION: Using SYSTEM, make the following patches to enable listing on any device.

1. Mount the system DECTape on Unit 0, WRITE LOCK.
2. Load SYSTEM at 17720.
3. When the computer halts, set AC switch 0=0, type C and depress CONTINUE.
4. When the computer halts, make the following core patches:

Address Switches	AC Switches
12325	002766
12345	000766
12347	002766
12364	000766
12366	002766
12562	002766

5. Set AC switch 0=1, type M and depress CONTINUE. ER will be output to the teleprinter, indicating that ~~MONITO~~ SYSTEM is unable to write on Unit 0. Put Unit 0 on WRITE ENABLE, type M, and depress CONTINUE. When the computer halts, the Monitor has been rewritten on the DECTape.

PROGRAM: KEYBOARD MONITOR (version dated 11/14/67)

PROBLEM: In configuration with API, occasionally a double PIC/API interrupt will occur.

SOLUTION: Using MONITO, make the following patch to inhibit these double interrupts.

1. Mount the system DECTape on Unit 0, WRITE LOCK.
2. Load MONITO at 17720.

3. When the computer halts, set AC switch 0=0, type M and depress CONTINUE.

4. When the compiler halts, make the following patch.

Address Switches	AC Switches
151	000401
256	740040
257	220255
260	600376
337	200006
340	705504
341	400356
342	620003
343	140000
344	120000
373	760111
374	200242
375	620367
376	060203
377	440255
400	620255
401	040152
402	750200
403	705512
404	740010
424	500547
425	040203
426	240344
427	060152
430	240343
431	741400
432	060242
433	600257

5. Set AC switch 0=1, type M and depress CONTINUE. ER will be output to the teleprinter, indicating that MONITO is unable to write on Unit 0. Put Unit 0 on WRITE ENABLE, type M and depress CONTINUE. When the computer halts, the Monitor has been rewritten on the DECTape.

Please note that this change will change the typeout of ".IOPS" to "I".

PROGRAM: MONITOR

PROBLEM: When using the system macro .TIMER, care must be taken not to do any Monitor calls (CAL), including .TIMER, in the subroutine handling the interval interrupt. Since the interval interrupt can occur at any point in the program, it is possible that it will occur while another Monitor call (CAL) is being processed. If a second were then issued, the program would blow up.

SOLUTION: A version of the Monitor will be distributed in the near future which will eliminate the problem.

PROGRAM: KEYBOARD MONITOR

PROBLEM: If a DECTape is used in the system immediately after having been formatted, an .IOPS 14 (directory full) error will occur.

SOLUTION: Before an attempt is made to use the tape, the directory must be cleared. This is most easily done by using the N command in the Monitor or the Z switch in PIP.

PROGRAM: EDIT

PROBLEM: The following problems exist in the version currently

in the field.

1. BLOCK mode will not work correctly if only the BLOCK ON command is issued. It is necessary to issue a TOP command immediately after the BLOCK ON command.

2. CLOSE NAME will not work if the OPEN command contained a NAME. Issue a CLOSE only and the file will be closed with the name given in the OPEN command.

3. Files are not manipulated correctly if .DAT slot -14 is assigned to DTA1(2-7) and .DAT slot -15 is assigned to DTA0. After closing the file will be on the scratch device (-15), rather than the input/output device (-14). This can be avoided by (1) assigning both -14 and -15 to the same device or (2) using PIP to transfer the file back to the original tape after the editing process is complete.

4. It is not always possible to delete the last line of a file.

SOLUTION: A new version of the Editor will be distributed in the near future which will eliminate these problems.

PROGRAM: LINKING LOADER

PROBLEM: The error message .LOAD3 is not listed in the manual.

SOLUTION: .LOAD 3 indicates a subroutine not found, which means that the Loader was unable to resolve a global. The name of the global, with an address field of all zeros, will be output to indicate what is missing.

C. PROGRAMMING NOTES

PI AND DEVICE HANDLERS

Disabling the PI by System Device Handlers

At the present time one device handler only (DECTape) keeps the PI off while servicing interrupts and three reasons for this are: (1) the timing between a change from search to read/write is critical (200 μ sec), (2) as a system device DECTape is so relatively slow that optimum response time seems desirable. Since interrupts from other devices can cause timing errors requiring reinitiation of DECTape I/O, response time could be adversely affected, (3) the maximum time during which the PI is normally off (97 μ sec) seems insignificant for all but very special systems. Now, either such systems should be equipped with API where the critical devices are placed on API levels higher than DECTape, or the user may easily alter the DECTape service routines if he has only a PI. Below is a time summary on the basis of function during which the PI is disabled. (DTDF is assumed to be first in the PI skip chain. 5 μ sec should be added to PI times for each position below the first.)

PI	API	Function
67 μ sec	58 μ sec	READ/WRITE complete
67 μ sec	58 μ sec	Search to Search in same direction
97 μ sec	88 μ sec	Search to Search, turn around
*127 μ sec	118 μ sec	Parity Error

67 μ sec is taken as both minimum and average given the relative frequency of the above functions.

Another note should also be made: select, mark track and EOT during READ/WRITE are considered irrecoverable and an exit to the Monitor is made, disabling all other I/O. A change would have to be made in environments sensitive to such an arrangement.

*Provided DTEF is placed high in the skip chain at SGEN time.

LINKING LOADER AND BINARY MODES

At assembly time, output modes (absolute/relocatable) should not be mixed in the same program. The assembler assumes relocatable mode until it encounters a .LOC with an absolute specification. Then it declares the entire program absolute. This can be disastrous at load time.

Example: If .LOC with an absolute specification is used within the body (not at the beginning) of a program, the entire program will be loaded, as though it were absolute binary, with a starting address of 0.

USING THE EDITOR IN LINE-BY-LINE MODE

The initial mode of the Editor is line-by-line, which is most useful for a fairly long program which has only a few edits. It is much faster than operating in BLOCK mode.

Unlike the Basic Editor, there is ~~the~~ ^{NO} need to issue a READ before editing can begin. It is necessary only to issue one of the locative requests; FIND, LOCATE or NEXT. NEXT will access the first line of the file, while FIND and LOCATE will access the line requested.

The example following assumes paper tape input. For purposes of illustration, the following short program will be the input file. Necessary changes are indicated in parenthesis.

```
C TEST
C 1-28-68 (Change date)
  READ(4,1)X (Incorrect FORMAT statement number)
  Y=X
  WRITE(3,10)X (Should be Y, not X)
10 FORMAT (F6.3)
  END (No STOP statement)
```

The underlined characters are those typed by the user; the others are responses made by the Editor.

```
EDITOR
>L L
  1-28-68
>C /1-28/2-2
  2-2-68
>N
>P
  READ (4,1)X
>C /1/10
  READ (4,10)X
>L W
  WRITE (3,10)X
>C /X/Y
  WRITE (3,10)Y
>F 10
  10 FORMAT (F6.3)
>
  INPUT
> ———> STOP
  ↓
  EDIT
>CLOSE
EDITOR
>
```

D. NEW AND REVISED SOFTWARE

PDP-7 REVISIONS

DEC-07-CDDA-PM DDT
DEC-07-CDDA-LA DDT Listing

PDP-9 NEW PROGRAMS

DEC-9U-EUMS-PH MONITO

MONITO enables patching of the Monitor and skip chain on the DECtape version of the advanced software. This program will automatically be shipped to customers with DECtape machines.

DEC-9U-EUSA-PH SYSTEM

System enables patching of all DEC supplied system programs, excluding DDT and the Linking Loader, on the DECtape version of the advanced software. This program will automatically be shipped to customers with DECtape machines.

DEC-9T-QFBA-PA FORTST

FORTST is a source program written in FORTRAN IV which is part of the checkout package for the advanced software, both DECtape and paper tape versions.

PDP-9 NEW MAINDECS (Tapes and write-ups)

MAINDEC-9A-D1EA-PH	Extended Memory Address Test
MAINDEC-9A-D6GA-PH	A-D Calibration Test
MAINDEC-9A-D6HA-PH	AF040 Diagnostic and Demo
MAINDEC-9A-D6JA-PH	339 PJMP Test
MAINDEC-9A-D6KA-PH	339 POP Test
MAINDEC-9A-D6LA-PH	339 Push Button Test
MAINDEC-9A-D6MA-PH	339 Instruction Test
MAINDEC-9A-D6NA-PH	339 Visual Display
MAINDEC-9A-D6OA-PH	Little Pictures for a 339
MAINDEC-9A-D6PA-PH	VF38 Search Logic Test
MAINDEC-9A-D6QA-PH	339 Character Generator Test
MAINDEC-9A-D6RA-PH	342 Character Generator Type in Program

PDP-9 REVISED MAINDECS (Tapes and write-ups)

MAINDEC-9A-D0HB-PH	EAE Part 2 Test
MAINDEC-9A-D1CC-PH	Extend Memory Control Test
MAINDEC-9A-D1DB-PH	Parity Option Test
MAINDEC-9A-D2FB-PH	CR01E Card Reader
MAINDEC-9A-D6AB-PH	Display 34H, 30D, 370
MAINDEC-9A-D7AB-PH	Basic Exerciser

PDP-9 DOCUMENTATION

DEC-9A-AM9B-D MACRO-9 Manual

This manual is a revision of the MACRO-9 Manual and includes corrections and some additions. It is not a major rewrite of the manual.

DEC-9A-C7AA-D PDP-9 Advanced Software Checkout Package

This write-up is a concise checkout test of the PDP-9 advanced software for both the paper tape and DECtape versions. It makes use of three tapes in addition to the advanced software: FORTST (DEC-9T-QFBA-PA), CANRUN7 (DEC-9T-QCAA-PA) and CANRUN9 (DEC-9T-QMAA-PA).

DEC-9A-AF40-DN Supplement #1 to FORTRAN IV: Advanced 8K DECtape Systems Software

Announcement of the small version of FORTRAN IV.

DEC-9A-AM9A-DN Supplement #1 to MACRO-9: Advanced 8K DECtape Systems Software

Announcement of the small version of MACRO-9.

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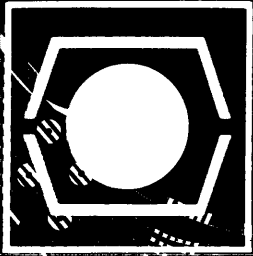
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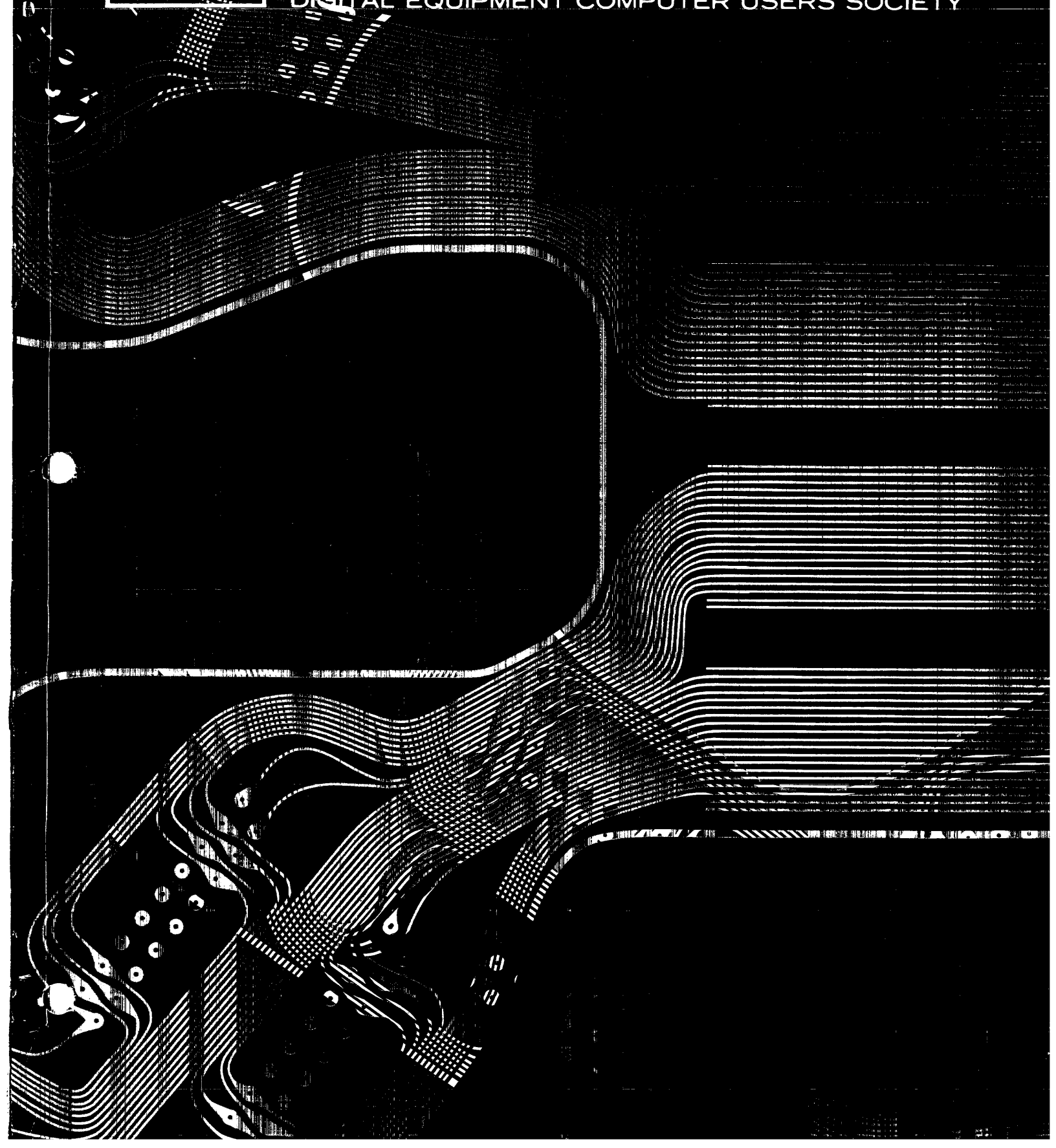
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DECUSCOPE

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LINUS IS ALIVE AND WELL IN A CONVERTED WOOLEN MILL IN MAYNARD MASSACHUSETTS.

Plotted by PDP-8 and CalComp

MEASUREMENT OF SPONTANEOUS MORPHOLOGIC VARIATIONS IN THE ELECTROCARDIOGRAPHIC P-WAVE*

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ABSTRACT

A real-time computer-oriented data acquisition and analysis system is described for measuring the spontaneous morphologic variations in the electrocardiographic P-wave. A waveform index is obtained by comparing each P-wave on a beat-by-beat basis with a reference P-wave. A graphic history of the P-wave morphology is produced by plotting this waveform index versus time. When structural changes in the P-wave are present the waveform index is further used to separate the P-waves into families and these families are averaged.

INTRODUCTION

During a recent investigation of the high-fidelity atrial electrocardiogram we observed and reported¹ a high incidence among normals of spontaneous structural changes in the P-wave. The magnetic tape recordings of the EKG's displaying this phenomenon were set aside pending development of suitable signal processing procedures. This communication describes our further work in detecting and analyzing changes in the shape of successive P-waves in long electrocardiographic data strings.

The technique we have developed uses a digital computer working in real-time with operator monitoring and control. As each EKG cycle is digitized the P-wave is time-aligned and compared with a reference P-wave resulting in a number called the waveform index. The computer thus maintains a beat-to-beat history of P-wave shape (along with the interval between beats) from which we obtain a grouping of the P-waves into families for averaging and analysis. The details of the data processing are given below.

METHODS AND MATERIALS

Data Acquisition System

Electrocardiographic recordings of seventy-one asymptomatic subjects were acquired during our preliminary investigation¹ of the P-wave. These are twenty-minute, FM, multichannel recordings of the standard bipolar leads, I, II, and III, at a gain of 2000, together with an impedance respirogram. At playback, these data are digitized and processed by a PDP-7 computer (Digital Equipment Corporation, Maynard, Massachusetts) with a thirty-two channel analog multiplexer, twelve bit analog to digital converter (ADC), point-plotting oscilloscope display, light pen and digital plotter.

Establishment of Time Alignment Among Successive P-Waves

Leads I, II, and III are directed to three channels of the multiplexer and digitized at 500 samples/sec/channel. Simultaneous

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neously the Lead-II record is conditioned for use as a control signal. It is applied to a differentiator with a time constant of 10 msec to minimize the effects of baseline instability and is further amplified. The inverted time-derivative signal is then heavily smoothed by a filter (Krohn-Hite Corporation, Cambridge, Massachusetts) with a pass-band of 2-30 Hz. The resulting measurement of R-wave slope is quite stable in shape and size from beat to beat. This control signal is digitized on a fourth channel and scanned for a specified point in its time course. Recurrence of this point in each cardiac cycle establishes a fiducial mark for time alignment of each QRS. If the P-R interval is constant the P-wave preceding each QRS is also aligned, despite changes in rate, shape of the P-wave, or baseline instability.

Measurement of Morphologic Variations Among Successive P-Waves

The procedure used for locating P-waves with respect to the fiducial mark and for establishing a reference (initial) set of P-waves is shown in Fig. 1. The program input buffer is filled from the ADC and Lead I of the first complete cardiac cycle is displayed (Fig. 1B). These data are displayed through a programmed "window" whose starting location (with respect to the fiducial Mark) and width can be changed to cause the window to bracket any part of the EKG cycle. Directing the light pen at the lower left-hand control point shifts the window to the right (Figs. 1A and 1C). Then direction of the light pen at the right-most boundary of the data desired produces narrowing of the window to include only the P-wave (Fig. 1D). Finally, directing the light pen at the lower right hand control point establishes these window parameters as the ones to be used in framing the P-waves of all three leads for every subsequent beat, and also causes the program to store the present three-lead set of P-waves as an arbitrary reference set.

Once a three-lead reference set of waveforms has been selected and framed, the morphology analysis program is initiated. As every beat occurs, the P-waves are located and a waveform index is computed for each lead indicating the degree of correlation between the present P-wave and its corresponding reference. These indices together with the current time between cardiac cycles (R-R interval) are punched on paper tape. Later this paper tape is input to a separate program which records the P-wave history and R-R interval history on a digital plotter.

The waveform index, our comparison criterion between the current P-wave and the reference waveform, is given by

$$A = \sum X_i Y_i / \sum X_i^2$$

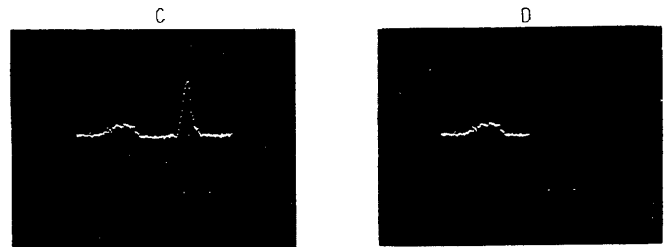
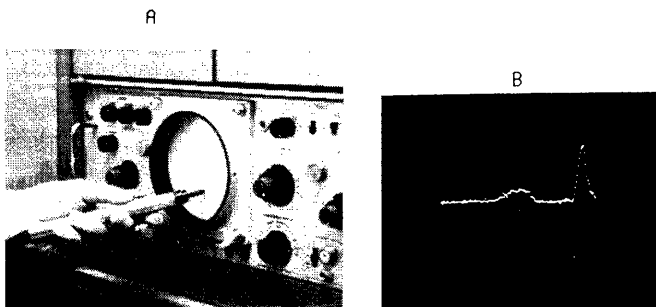


Fig. 1. Establishment of location of P-wave. (A) Light pen and display. (B) first complete cardiac cycle of Lead I displayed with control points below; (C) display after shift caused by directing light pen at lower left-hand control point; (D) display after directing light pen at right-most boundary of data desired.

where the X_i are the reference P-wave data (with their average removed) and the Y_i are the data of the corresponding time segment of the current cardiac cycle. This index is a least-squares measure of how much reference signal is contained in a given subsequent waveform. If the two are identical the index is unity; if they are not identical the index generally differs from unity.

Monitoring

The acquisition and analysis of the data, and the production of the paper tape output are parallel computer operations. While one part of the program is continually acquiring data and storing it in a program buffer, a second part is analyzing these data, and a third part is punching the last results. Since analysis and output production are much faster than acquisition, the time spent awaiting the arrival of data is used to produce a dynamic display with the information shown in Fig. 2. This information consists of the most recently acquired set of P-waves and the history of the waveform indices and R-R interval for the last two hundred beats. The display is updated with each heart beat by moving the present P-wave into the display buffer, shifting the information in the history buffer left one position and placing the present calculated waveform indices and R-R interval in the last position of the history buffer. The top left illustration in Fig. 2 shows an example of the display observed by the operator during a single heart beat. The lower

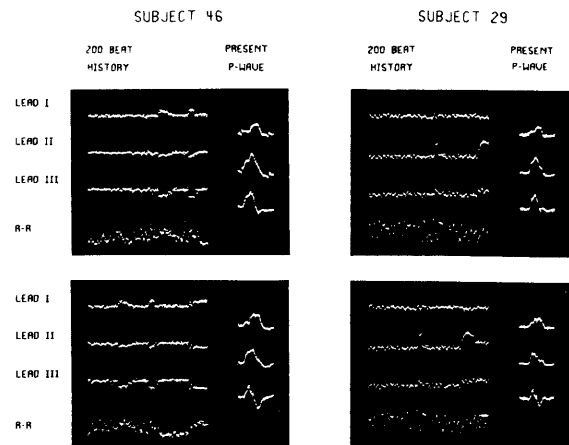


Fig. 2. Top left: Real-time dynamic display of a set of P-waves of Subject 46 with 200-beat history of P-wave morphology and R-R interval. Bottom left: Dynamic display for same subject a short time later showing a change in the P-wave which is also evident from a change in the right-hand level of the morphology history. Right hand: Dynamic display observed at two different times during analysis of second subject.

left illustration in this figure shows it a short time later. It is evident from the P-waves themselves that a change has occurred and the existence of this change is noted from the shift that has occurred in the level of the waveform indices. This dynamic display allows the operator to monitor variations in P-wave structure as they occur. The illustrations on the right in Fig. 2 are another example of the display observed at two instants during the analysis of a second subject.

Separation of Waveform into Families and Averaging

During the analysis of variation in morphology described above, frequency distribution of the waveform indices for each lead are stored in memory. After the termination of the analysis the frequency distribution of any specified lead can be displayed as shown in Fig. 3. The abscissas of the illustrations in Fig. 3 are the waveform indices encountered during the analysis. The ordinates are the frequency count for each index. The extremes

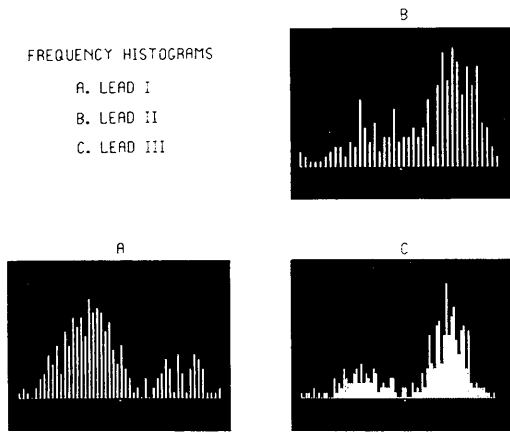


Fig. 3. CRT displays of frequency histograms used to separate P-waves into families. Abscissa is waveform index encountered during morphology analysis and ordinate is corresponding frequency count. Control point below histogram indicates last index read out by light pen and is initially in center. (A) Lead I; (B) Lead II, (C) Lead III.

of the waveform indices which occurred are found and the density of the histogram adjusted for maximum resolution or the display. Besides allowing us to determine quantitatively which P-wave structures are predominant and which are rare, the grouping of waveform indices also permits averaging those waveforms that clearly belong to a single family. As to be expected,¹⁻⁶ this averaging of a number of waveforms greatly enhances the signal-to-noise ratio of the P-wave. The point intensified in the middle and below each histogram can be moved by the light pen to read out the value of any of the displayed waveform indices. The operator selects the lead which manifests optimum separation of the families and then, using the light pen, reads out the mean waveform index of each family.

To average the members of any family, the operator specifies the mean waveform index of that family, a tolerance interval, the number of complexes to be averaged and the lead to be used for selection. Then the averaging process is initiated. As every beat occurs, the waveform index is computed for each lead. Next the value of the waveform index of the selection lead is compared against the acceptable interval. If it falls within this interval, the entire complex (not just the P-wave)

of each lead is added to its respective image in memory. When the specified number of complexes have been acquired, a paper tape of the three averaged waveforms and the averaged R-R interval is punched for further analysis and/or plotting of the averaged families.

RESULTS

P-Wave Morphology and R-R Interval Histories

Figures 4 and 5 are P-wave morphology and R-R interval histories for four typical subjects. These histories were plotted using the output paper tapes of the morphology analysis program. They span approximately twenty minutes or 1200 beats.

The sinus arrhythmia apparent in the R-R interval history of 12 in Fig. 4 was visually verified by monitoring the impedance respirogram and the electrocardiogram on a cathode ray oscilloscope. The same cyclic component in this R-R interval history can also be seen in the Lead-I history, demonstrating a respiratory component in the waveform index. The fluctuations in the Lead-II history of this subject are seen to be principally noise; and the Lead-III history manifests both a respiratory component and a noise element. The other three subjects, 52, 46, and 13, exhibit structural variations of the P-wave which cannot be attributed to noise effects or respiration. At three different times, Subject 52 had a P-wave which changed for 50 beats or more. The transitions from one P-wave morphology to another are seen to have occurred within five beats and the P-wave was relatively stable until the next change occurred. A slight change in R-R interval can also be discerned in this history when some of the transitions occurred.

The history of Subject 46 in Fig. 5 manifests frequent variation of the P-wave. It exhibits a P-wave which sometimes changed in one beat, while at other times took as many as 25 beats to make the transition from one P-wave morphology to another. Close inspection of this history would seem to indicate that the values of the waveform indices tend to gather around three distinct levels, suggesting the presence of three families of P-waves.

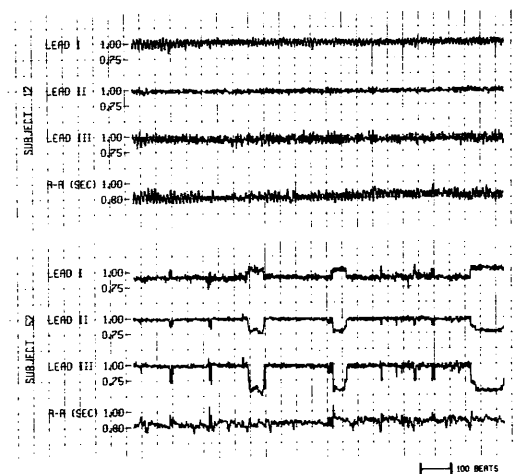


Fig. 4. Two typical P-wave morphology histories. Top: History with sinus arrhythmia in R-R interval, respiratory component in Leads I and III, and no major change in P-wave structure. Bottom: History with three major changes in P-wave structure lasting for 50 beats or more.

Subject 13 in Fig. 5 is seen to have a P-wave which changed infrequently and for, at most, 17 beats. Interestingly, the changes in R-R interval accompanying the transitions in P-wave shape in this history are opposite to those of Subject 52 in Fig. 4.

Averaged P-Waves

The output paper tapes of the averaging process are used as input to a separate program which corrects any low frequency distortion produced by the recording equipment and plots the averaged families on a digital plotter. Figure 6 illustrates the fifty-beat averaged set of P-waves for two distinct families of a typical subject and indicates those complexes of the history which were used to acquire the averages. Although the entire complexes were available, only P-waves are shown here so they can be seen in detail. The history itself exhibits a sinus arrhythmia in the R-R interval and a respiration component in all three leads. The shape of the P-wave at one time in this history is seen to have undergone a transition taking almost 50 beats.

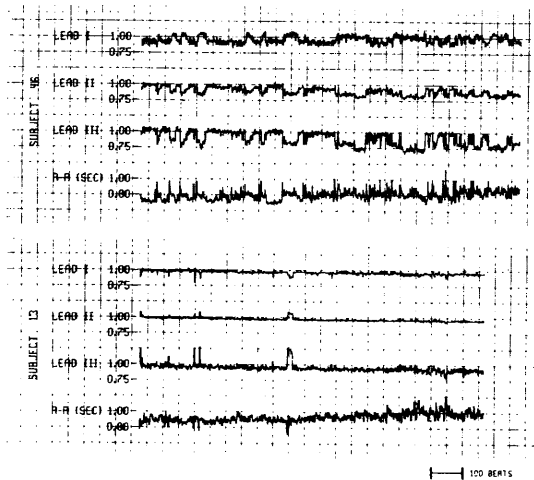


Fig. 5. Two typical P-wave morphology histories. Top: History with frequent changes in P-wave structure. The three quiescent levels indicate the presence of three distinct P-wave families. Bottom: History with several unsustained changes and a major change of only 17 beats duration.

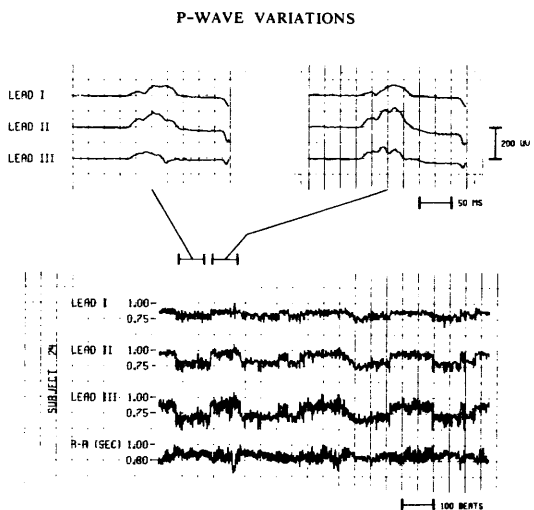


Fig. 6. Results of selective averaging of two P-wave families belonging to the same subject and an indication of those complexes of the history which were used to acquire averages.

When respiratory effects are present the frequency distribution of the waveform indices for any single family is bimodal. Thus the mean waveform index of each respiratory phase can be used to find the average P-waves of this family during inspiration and expiration. Figure 7 is an example of a single family averaged in each phase of respiration.

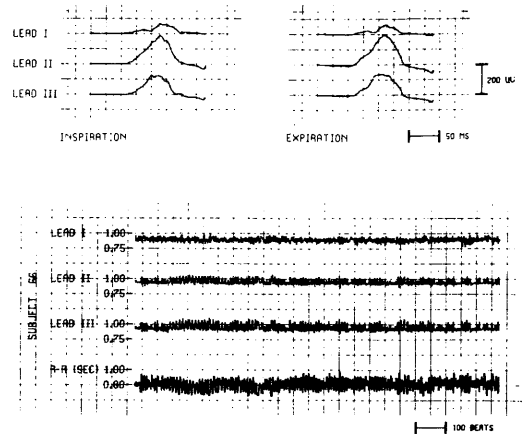


Fig. 7. Results of selective averaging of a single P-wave family in each phase of respiration.

DISCUSSION

Of the various methods considered to measure the changes in P-wave structure, none would uniquely describe all possible waveforms. Thus the decision to use the waveform index is based on expediency in calculation; and then, since a change in the waveform index is a sufficient but not a necessary condition to indicate a change in P-wave structure, the separation of P-waves into families is based not on any one lead but on the results of the calculation of the waveform index on all three leads. Using this approach, we have never observed a significant change in P-wave morphology on the dynamic display which was not accompanied by a change in the waveform index level on, at least, one of the three leads.

While the specific intent of this investigation was to measure morphologic changes in the P-wave, the waveform index is sensitive to any deviation from the reference waveform. Hence, the moderate decline in index level from the beginning to the end of the histories of both subjects in Fig. 5 may be due to a lengthening of the P-R interval. The waveform index was found to be relatively unaffected by noise or a shift in the starting time of the analysis. Monitoring of the display during the real-time analysis revealed P-waves which were almost completely obscured by noise. Yet the waveform indices of these P-waves exhibited only minor differences from the waveform indices of "clean" P-waves belonging to the same family. This indifference to noise was further demonstrated by an experiment which used an averaged set of P-waves as the reference set. Although this reference set had considerably less noise than a set derived from a single beat, the resulting history showed no perceptible increase in the signal-to-noise ratio. Figure 2 demonstrates the effect of a shift in the starting time of the real-time analysis. Since the computer had to be stopped to acquire the illustrations in Fig. 2, the first and second row of illustrations are the results of independent analyses which, in all probability, were not begun at the same point in the analog record. Comparison of the same events in the two resulting histories reveal insignificant differences. Con-

trary to the effects of noise and a displacement in the time of origin, changing the reference set of P-waves may alter the history considerably. The sequence and duration of the variations, nevertheless, will remain the same; and the value of the waveform index while being different between the histories will be the same within a given family and history.

Of the 71 normal subjects examined during this study, 41 were found to have spontaneous variations in P-wave morphology. The high incidence of this phenomenon appears to have gone unreported prior to our publishing of the preliminary results of this investigation.¹ Presumably, the reasons for this are two-fold. First, the clinical EKG consists of less than 150 beats and thus, with subjects whose P-wave changes infrequently, an inauspicious choice in the time of recording could obviate any variation in this interval. The morphology history of Subject 13 in Fig. 5 demonstrates structural changes in the P-wave which could easily be overlooked for this reason. Secondly, the poor amplitude resolution of the clinical EKG restricts the recognition of this phenomenon to gross changes in P-wave shape, such as pronounced flattening or outright inversion. It is improbable that the structural differences existing between the two averaged P-wave families in Fig. 6 would be noted in a clinical EKG.

By revealing the prevalence of spontaneous morphologic changes in the P-wave, our previous investigation¹ demonstrated the hazards of indiscriminant averaging of the P-wave and introduced a new set of questions: what are the specific structural changes in the P-wave; what are they caused by; how are they affected by posture, by exercise, by drugs; and many more. The results of our present study furnish the necessary techniques for a detailed examination of this phenomenon to answer these questions. The morphology history provides a means of studying the temporal relationships and a critical analysis of the structural changes is now possible due to the selective averaging process. Thus the further application of these techniques may contribute significantly to refining the definition of normal atrial activation.

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ACKNOWLEDGMENT

The DECUS Executive Board would like to express its sincere appreciation to all those who participated in the recent DECUS Spring Symposium. Special thanks to all the chairmen: Prof. Philip R. Bevington, Thomas Day, Dr. Sylvia Charp, Richard J. McQuillin, Michael S. Wolfberg, Prof. Belmont Farley, who did an excellent job in seeing that each session was run efficiently.

This year's meeting boasted an attendance of 270 with papers and special topic workshops. Our thanks to all the speakers: Prof. John W. Carr, III, David W. Roberts, Dan W. Scott, Phylis F. Niccolai, Paul Shrager, D. Reimer, R. Van Berg, C. A. Bailey, John Rayner, John Alderman, Michael L. Doren, Bud Pembroke, Richard R. Karash, Dr. John Elder, K. E. Rigg, Dr. David M. Robinson, Mrs. Judith B. Edwards, Richard J. McQuillin, Richard Falt, D. M. Forsyth, Philip R. Bevington, David Z. Polack, David Leny, James Murphy, Charles Conley, A. E. Sapega, Jeffrey H. Kulick, George E. Friend, David Garfinkel, J. R. Millenson, Dr. Karl Lowy, Harold W. Shipton, David R. Friesen, R. L. Simpson, Rick Merrill, Richard Martin. Each did a fine job in presenting well-prepared papers and workshops.

The activity of this meeting illustrates the increased growth and interest in DECUS, and it is hoped that we will continue to grow in the future.

Plans for the Fall Symposium are tentatively set for San Francisco on Thursday and Friday, December 12 and 13, following the Fall Joint Computer Conference. Specific details on the meeting will be out as soon as possible.

PROGRAMMING NOTES

SINGLE-INSTRUCTION OPERATION OF PDP-8 FORTRAN (4K)

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Naval Research Laboratory
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In PDP-8 FORTRAN (4K) operations, the need arises occasionally to run a particular object program on the basis of one FORTRAN instruction at the time. It appears that this feature is not discussed anywhere in the PDP-8 FORTRAN manual, or in any of the DECUS publications.

There is an easy method to obtain this feature--simply change the contents of location 100 from 401 to 400 in the FORTRAN Operating System. With this change incorporated in the OP SYS, the FORTRAN program will HALT at location 400 after execution of each interpretive command in the user's FORTRAN object tape. To ascertain where the program is after one of these HALTs, turn ON the SINGLE STEP switch on the PDP-8 console. Then use the CONTINUE switch to step through the instructions at 401 and 402. The instruction at 402 is TAD I 14; watch the panel lights for display of the contents of location 14, the FORTRAN instruction location counter. Press CONTINUE once more and obtain the contents of the contents of location 14, which is the command code for the next interpretive command in the user's FORTRAN object tape.

To continue through the execution of another FORTRAN instruction, switch SINGLE STEP to OFF and press CONTINUE; the OP SYS will execute another FORTRAN instruction and HALT at 400 once more.

The user can determine how far his program has been executed by recognizing landmarks in his program in terms of the interpretive codes displayed on the PDP-8 panel as contents of the contents of location 14. For example, DO is code 20, CONTINUE is code 47, IF statement for fixed arguments is code 50, DECTape pseudoread is code 54, etc. A listing of all interpretive codes is found in the OP SYS library write-up.

It is permissible to examine contents of any memory location when the FORTRAN program is at one of these forced HALTs, provided that the user is careful to restart the program at address 401 after examining memory.

The single-instruction feature can be removed at any one of the forced HALTs for the purpose of continuing uninterrupted through the rest of the program, by restoring location 100 to its original 401 contents.

Another option available with this FORTRAN single-instruction feature involves the use of Octal Memory Dump (Digital 8-6-U Sym, ref. p. 301, Small Computer Handbook 1968) assembled with a starting address of 7600, and subsequently converted to RIM format by DEC-08-PMPA-D (RIM Punch, p. 301, Small Computer Handbook 1968). At any one of the forced HALTs the Octal Memory Dump can be read into memory, over the BINARY loader, by use of the RIM loader, and then used to dump sections of memory where the FORTRAN variables (iden-

tified by SYMBOL PRINT) are stored. It is suggested that in Octal Memory Dump, the contents of 7665 be changed from 7774 to 7775 so that it will type out memory contents in terms of three locations per Teletype line, consistent with the floating point number format.

FROM: A. K. HEAD
C.S.I.R.O. AUSTRALIA

The idea on page 10 of DECUSCOPE, Vol. 6, No. 5, for punching a copy of a binary tape during loading has proved very useful although a different set of changes was necessary for Binary Loader DEC-08-LBAA-LA. These were

7661	7000	7702	6046
7670	6041	7712	3267
7672	6046	7752	5273
7673	5660	7753	7775

On experimenting with CALCULATOR it was found that on repeat, although

1 [* - 1] gives -1, +1, -1, +1, . . .

and -1 [* - 1] gives +1, -1, +1, -1, . . .

as might be expected,

-1 [+1] gives -2, -3, -4, . . .

-1 [-1] gives 0, 1, 2, 3, . . .

(-1) [+1] gives 0, 1, 0, 1, . . .

which are curious but useful.

If a number of similar expressions are to be evaluated by CALCULATOR it is convenient to put the constant parts on tape, separated by null tape where it can be stopped and the appropriate numbers typed in. Blank tape, as generated by the HERE IS key, is suitable but leader/trailer is not.

FROM: THE UNIVERSITY OF MARYLAND
DEPARTMENT OF PHYSICS AND ASTRONOMY
COLLEGE PARK, MARYLAND

The following program written by R. E. Hummer is useful to initialize core to HLT before loading a program for debugging.

4/7402	HLT
5/1004	TAD 4
6/3410	DCA I 10
7/5005	JMP -2
10/10	

This program will place HLT everywhere except 6, 7, 10.

This next program was written by L. C. Wang. It will clear all core to zero.

```

*4
0004/1005  START, TAD      .+1
0005/3410          DCA I IX
0006/5004          JMP      START
0007/5404          JMP I   START
0010/0011  IX,      .+1
0011/2010          ISZ      IX
$

```

1. Using the TAD, DCA, JMP Loop, this program will first deposit 3410 (=DCA I IX) in all the locations from 0012 to 7777 and from 0000 to 0004.

2. When the content of location 0004 is changed to 3410 (=DCA I IX) the next two loops will deposit 0000 (=AND 0)

in locations 0005 and 0006 and the JMP I START instruction in location 0007 will cause an effective jump to location 3410.

3. From 3410 to 7777, every location contains 3410 (=DCA I IX). This will clear location 0001 to 0010 repeatedly.

4. When the instruction DCA I IX in location 0000 is executed, the content of IX will be 0007. The AND instructions in location 0001 to 0010 have no effect, and the ISZ IX in location 0011 will change IX into 0010.

5. From 0012 to 7777, every location contains 3410. This will clear locations 0011 to 7776.

6. The 3410 in 0000 will clear 7777 and IX now contains 7777. Every location other than 0000 and 0010 are cleared.

7. The 3410 in 0000 cleared itself and increased IX to 0000.



FROM: WILLIAM McNAMARA
DIGITAL EQUIPMENT CORPORATION
MAYNARD, MASSACHUSETTS

PDP-9 SKIP ON FLAG

Skip chains for the identification of an interrupt can be more efficiently implemented, for more than a few devices, by reading a status word and microprogramming a rotate and skip instruction to test the word. This comes about because of the 4 μ sec I/O cycle time for a skip instruction as opposed to the

1 μ sec execution time of a microcoded operate instruction. Use of the status word technique provides a flexibility not available in the I/O skip method because it is possible to invert the sense of a flag with an XOR, or by inverting the sense of a skip micro. A further capability is to ignore particular flags by ANDing a mask with the status word. A typical skip chain is shown below.

Efficiency can be increased and break-even point lowered by omitting the XOR and AND instructions. If we are sure a flag has been read, we can gain a microsecond by making the initial set-up instruction SPA V RTL.

```

70XX12          /READ STATUS WORD                4  $\mu$ sec
XOR WORD1       /INVERT FLAG SENSE PER WORD1      2  $\mu$ sec
AND WORD2       /MASK OUT UNUSED FLAGS           2  $\mu$ sec
SNA V RCL       /SET UP FIRST TEST
                /SET UP EXIT IF NO FLAGS          1  $\mu$ sec
JMP EXIT        /LEAVE IF NO FLAGS
SZL V RCL       /TEST FIRST FLAG
                /SET UP SECOND                    1  $\mu$ sec
JMP FLAG1      /
SZL V RCL       /TEST SECOND FLAG
                /SET UP THIRD                      1  $\mu$ sec
JMP FLAG2      /
SZL V RCL       /ELAPSED TIME INCLUDING THIS
                /INSTRUCTION, 12  $\mu$ SEC EQUALS
                /THREE I/O SKIPS. THIS IS THE
                /BREAK-EVEN POINT.

```

FROM: J. R. STOREY
 DEFENCE RESEARCH TELECOMMUNICATIONS
 ESTABLISHMENT, CANADA

some of the temporary storage registers used in the loaders,
 and then use it to clear most of memory including the original
 program.

Several methods have recently been published in DECUSCOPE
 on the needs for an absolute clear, but in most cases one needs
 to keep the loaders intact and clear the rest of the memory.
 One method which is so simple that it must have occurred to
 many is a program that transfers a simple wipe-out loop into

The program below uses locations 7612-7616 in the DECtape
 Library System Loader (Digital-8-3-U) as the iterative loop
 to clear memory. Locations 7657 and 7661 are used as tem-
 porary storage. The program exists by returning the user to the
 DECtape Library System.

/WYPOUT
 /WIPES OUT ALL OF MEMORY EXCEPT LOADERS
 /WYPOUT USES TEMPORARY STORAGE LOCATIONS OF LOADERS.
 /PROGRAM WRITTEN FOR PDP5 WITH DECTAPE AND 552 CONTROL.

		*7600		
7600	1223	EXIT,	1223	
		*7612		
7612	0000	CLEAR,	0	
		*7657		
7657	0000	ADDRESS,	0	
		*7661		
7661	0000	TOTE,	0	
		*200.		
0200	7300	BEGIN,	CLA CLL	
0201	7001	IAC	/NOP FOR PDP8	
0202	3632	DCA I	ADD	
0203	1234	TAD	NUMBER	
0204	7040	CMA		
0205	3633	DCA I	TOT	
0206	1236	TRANSFER,	TAD M5	
0207	3237	DCA	COUNT	
0210	1223	TAD	PROGADD	
0211	1235	TAD	M1	
0212	3011	DCA	11	
0213	1231	TAD	CLR	
0214	1235	TAD	M1	
0215	3012	DCA	12	
0216	1411	MOVE,	TAD I 11	
0217	3412	DCA I	12	
0220	2237	ISZ	COUNT	ADD 0232
0221	5216	JMP	.-3	ADDRESS 7657
0222	5631	JMP I	CLR	BEGIN 0200
0223	0224	PROGADD,	PROGRAM	CLEAR 7612
0224	3657	PROGRAM,	3657 /DCA I ADDRESS	CLR 0231
0225	2257	2257	/ISZ ADDRESS	COUNT 0237
0226	2261	2261	/ISZ TOTE	EXIT 7600
0227	5212	5212	/JMP CLEAR	MOVE 0216
0230	5200	5200	/JMP EXIT	M1 0235
0231	7612	CLR,	CLEAR	M5 0236
0232	7657	ADD,	ADDRESS	NUMBER 0234
0233	7661	TOT,	TOTE	PROGAD 0223
0234	7576	NUMBER,	7576 /7577 FOR PDP8	PROGRA 0224
0235	7777	M1,	7777	TOT 0233
0236	7773	M5,	7773	TOTE 7661
0237	0000	COUNT,	0	TRANSF 0206

FOCAL POINTS

We are inaugurating a new column to serve as a forum of comments and/or programs written in DEC's new family-of-8 conversational language, FOCAL. These programs and examples will be kept in printed form only and will usually be distributed in groups. Initially these categories are Engineering, Plotting, and Mathematics. Other group headings will no doubt be added rapidly. Anyone desiring a set or sets of these write-ups should write the DECUS Office, Maynard, Massachusetts 01754, indicating the category desired. Abstracts of existing routines follow. Each program submitted either to an existing category or as a new category should be submitted with a listing, an example of execution, and a brief abstract which will be printed in this column. We may also reproduce some results of their operation.

This column will serve to disseminate information about modifications to the FOCAL system for special applications. However, the FOCAL program itself and its documentation will be distributed from the DEC program library.

For those who haven't heard, FOCAL (FOrmula CALculator) is a 4K conversational language with fourteen (14) functions and sufficient capacity to solve 6th order simultaneous linear equations. It can be used as a sophisticated desk calculator or programmed to solve complex problems. It may also be used in certain real-time applications. The scope and A/D functions are already built into the program, and other functions can be added.

Example:

```
*GO

ROUTINE TO SOLVE MATRIX EQ. AX=B FOR X
ENTER DIMENSION OF A, THEN
ENTER COEFF'S A(J,K)...A(J,N) AND B(J)
:3

:1 :2 :3 :4
:4 :3 :2 :1
:1 :4 :3 :2
X(=+ 0) =+ 0.000000
X(=+ 1) =- 1.000000
X(=+ 2) =+ 2.000000
```

```
*      *****
      **      **
      *        *
      **      **
      *****
      *****
      *****
      *****
      **      **
      *        *
      **      **
      *****
```

FOCAL ABSTRACTS

Plot Routines

One Line Routines - Demonstrates the ability to create a one line program, loop to plot using library functions of the FOCAL language.

X-Cubed and Circle - Use of subroutines in function plotting.

Superposition - The ability to superimpose multiple functions with different print characters in one output plot.

Circle - A circle of radius 10 plotted by residuals.

Mathematics

Simultaneous Equations - A familiar multi-variable problem is solved for 1st - 6th order equation sets (9th order if extended functions are gone).

Curve Fittings - Plot of exponential equation.

Abbreviated Simultaneous Equations

Education

Sines - Plotting several variables using sine functions.

Factors - Determines whether a number is prime or gives its factors.

Figure Eight - Will plot various sizes of figure eights by means of residuals. This is represented by a simple fourth order equation.

Right Triangle Solutions - Applies trigonometry relations and the Pythagorean theorem for a right triangle.

Engineering

Column Width - Used for typesetting calculations.

Traverse - A Civil Engineering and Surveying Application to compute a closed traverse given bearings and distances.

Least Square "Linear" Fit - Finds slope and Y-intercepts for the equation $Y=MX+B$ given a set of data observations.

Nozzle Weight Flow - Checks inlet pressure ratio and calculates the weight flow through the nozzle (from Hamilton Standard).

Filter Design - Plots filter output as well as numerical answers to a digital filter design problem.

OHM's Law

SOFTWARE FOR SALE

The programs listed below may be purchased or leased. Pricing information should be obtained directly from the supplier. DECUS makes no charge for announcing these programs and reserves the right to discontinue this service at any time. DECUS cannot guarantee the accuracy of these announcements. A complaint file will be maintained at the DECUS office for each offering and this file may be inspected by any DECUS member.

Programs will be announced for sale or lease only if they are submitted on behalf of corporations; no individual person may offer a program for sale or lease through DECUS.

AGRIPPA-ORD Corporation is offering for sale the following Linc-8 programs.

PLAP ASSEMBLER

1. Completely compatible with the Lap-6 utility system.
2. Assembles Linc code or PDP-8 code or both.
3. Six letter tags - 2047 user defined symbols.
4. Error diagnostics with listing.
5. Produces up to 16 blocks of binary.
6. Will load PDP-8 code into Bank 0 (new LO command).

CALCOMP PLOTTER ROUTINES

1. Three subroutines: Plot alphanumeric, Plot graph, Plot line drawings.
2. Size - two quarters each subroutine (easily overlaid).
3. Self-relocating into any two consecutive quarters of Field 0 (lower 4K of PDP-8 memory).
4. 100 % PDP-8 code - runs with the interrupt enabled - the Linc program can assign a task and go about its business.
5. Array driven, will plot text buffers, graph buffers, histogram buffers, or line drawings.
6. Data may be half or full-word packed, interleaved or sequential, and reside in any size machine.
7. Conversational subroutine driver supplied free of charge with purchase of three subroutines.

ISOMETRIC SCOPE DISPLAY

1. Displays isometric surface, 3D histogram or slices along X or Z axis.
2. Size - three quarters (1, 2, 3).
3. Data may be half or full-word packed, interleaved or sequential, up to 30K.
4. Display may be scaled, complemented and inverted.
5. Subroutine is called with four operands.

GRAPH AND TEXT DISPLAY

1. Displays half-word packed Linc text strings and/or graph data.

2. Size - two quarters (binary for any two consecutive quarters).
3. Performs an operation (nop, add, subtract, multiply, divide) between two half or full-word packed data sets and displays result on the scope. If the operation is "nop," data set 1 is displayed.
4. Cursor, histogram, and scaling options.
5. Subroutine is called with nine operands.

† TEST SUBROUTINE

1. Computes and stores † Test values for related points of two data sets.
2. Size - three quarters (1, 2, 3).
3. Data sets may be half or full-word packed, sequential or interleaved, up to 2047 points each. An entry in a data set consists of a 12 bit mean value (6 bit optional) and a 12 bit standard deviation (6 bit optional).
4. Biased or unbiased option.
5. Subroutine called with 11 operands.

CORRELLATION SUBROUTINE

1. Generates the correlation function and correlation coefficient between two data sets at a specified lag value.
2. Size - three quarters (1, 2, 3).
3. Data sets may be half or full-word packed, sequential or interleaved, up to 1023 points each.
4. "Tail wrapping" option.
5. Subroutine called with nine operands.

CURVE FITTING SYSTEM

1. Keyboard or tape entry of 128 7-digit number.
2. Conversational operation.
3. Data and "best fit curve" can be displayed.
4. Analysis routines are completely modular - new versions may be added easily.
5. Present version includes: polynomial least square approximations, simple linear regression, log-log and semi-log displays and multiple partition approximations, error analysis, and correlation coefficient.

For further information on these and other, more specialized, programs contact:

N. David Culver, President
AGRIPPA-ORD Corporation
Monument Square
Carlisle, Massachusetts 01741
Phone: (617) 369-2912

"LETTERS"

"Dear Mrs. Cossette:

"The addition of DECUS 5/8-28a, "Phoenix Assembler, PAL III Modification" was heartily welcomed to the library.

"Some people may have a high speed reader but no high speed punch with their PDP-8 or PDP-8/S. Having a high speed reader, however, makes one want to speed up the process even further. To do this I have made the following changes in the Phoenix Assembler.

<u>Location</u>	<u>Old Content</u>	<u>New Content</u>
0200	6032	6016
1465	6031	6011
1467	6036	6016
2471	6031	6011
2475	6032	6012
2501	6034	6014
2505	6036	6016

"These changes are most easily effected by using DDT and punching out a new binary tape. The highest location for Phoenix is 2737, so one can see that it easily fits in the available space of DDT.

Very truly yours,

Geo. Lewis Helgeson
Helgeson Nuclear Services, Inc.
872 Abbie Street
Pleasanton, California 94566

"Dear Mrs. Cossette:

"I would appreciate hearing from anyone who has used a PDP-8 computer and magnetic disc to drive an X - Y display. I am interested in both the hardware and software aspects of this problem.

Yours sincerely,

M. D. Levine, Assistant Professor
Department of Electrical Engineering
McGill University
Montreal
CANADA

"Dear Mrs. Cossette:

"In answer to Mr. Hyman's letter of September 13, 1967, requesting information on handling large volumes of paper tape, we submit the following:

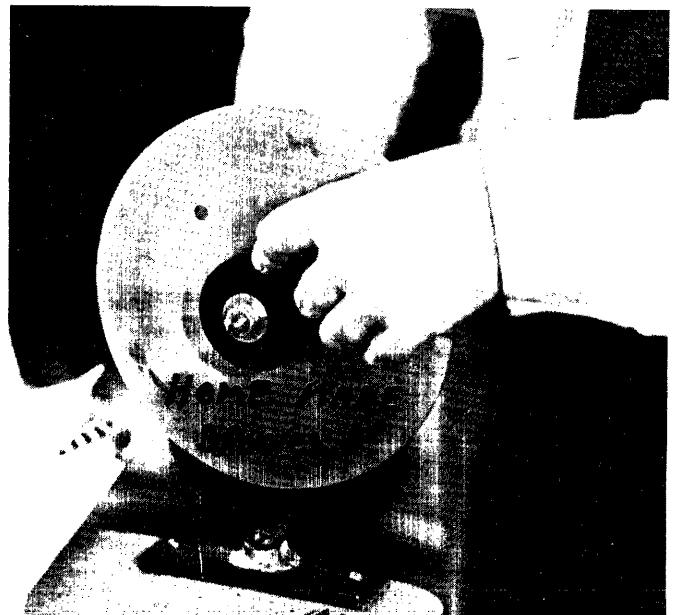
"The first step taken was to modify all tape reels to take a standard 8 1/2 "Tally" reel.

"The use of an automatic tape reeler with the H/S reader was discontinued because of repeated tape breakage. It was replaced with a tape box and a large plastic pail (see enclosed photo). Hand spoolers were fabricated by modifying inexpensive bench grinders.

"Several photos of tape handling facilities at the Institute are also enclosed.

Yours very truly,

A. D. Parsons
Computers/Microwave Systems,
for Director, Atlantic Oceanographic Laboratory
Bedford Institute
P.O. Box 1006
Dartmouth, Nova Scotia
CANADA"



"Dear Mrs. Cossette:

"I wish to comment on the interesting note by R. Krishna on negative input level conversion, which appeared in the latest issue of DECUSCOPE (Vol. 7, No. 1). The problem was that of reading 38 inputs into the PDP-8 accumulator, each having voltage levels of 0 and -6 volts (logical "0" and "1" respectively). His solution, which consisted of an arrangement of W002 and R001 modules, is quite ingenious and is indeed cheaper than using W511 level converters.

"Upon closer examination, however, one sees that the whole problem can be avoided by feeding the 0 and -6 volt levels directly into the R123 read-in gates without any conversion at all. This is permissible since for input voltages below -3 volts, the input diode of an R123 gate is reversed biased, and the result is the same as having a -3 volt input. For a 0 volt input the gate works in the normal manner. This procedure requires no additional logic beyond the original seven R123 read-in gates. It also, of course, circumvents the problem inherent in Krishna's solution of having a diode voltage drop for ground level signals.

Cordially,

J.D.A. Griffin, Engineer
Research Division
Ontario Hydro
200 Kipling Avenue South
Toronto 18
CANADA

"Mr. R. Krishna
Department of Electrical Engineering
University of Saskatchewan
Saskatoon, Saskatchewan, Canada

"Dear Mr. Krishna:

"I recently read the 1968 Volume 7, No. 1 edition of Decuscope and noticed the article on Negative Input Level Conversion submitted by you. I would like to thank you for contributing to Decuscope and hope you will continue to do so in the future.

In regard to your article, I would like to point out that standard DEC modules such as the R111, R123, R113 etc. can accept a -6V to 0V input without any modification or additions. The diode inputs in these modules are D664 diodes which are rated at 25V PIV. This allows a much greater voltage differential at the input than the standard 3 volt swing which we advertise.

In addition to saving money, since the input signal can be fed directly into the R123, the noise rejection is improved. As you pointed out in your article, load current flows through diode D1 when the input signal is at ground. By feeding the output of this buffer directly into an R123 the noise rejection would be decreased by the amount of drop across the diode.

Once again I would like to thank you for your article. If I can be of any service to you, please do not hesitate to contact me.

Very truly yours,

Martin S. Gordon
Supervisor of Module Applications"
Digital Equipment Corporation
Maynard, Massachusetts"

MODULE USERS NEWS

MODULE USERS GROUP PROGRESS

About 100 DECUS members have now joined the new Module Users Group within the hardware section of DECUS. The first project to be undertaken, aside from meetings and papers, will be an intra-group consulting service based on the questionnaire bound in this issue of DECUSCOPE.

By submitting one or more of these you will be offering to be contacted by another "MUG" member who is about to undertake a project similar to one you have completed. With the help of enough MUG members, the resulting file in Maynard can become a valuable index to advice and information.

To avoid placing an unfair burden on those most experienced, it is suggested that each MUG member submit just one entry. Longtime users should choose an application that seems to offer their most valuable wisdom in terms of timeliness and general utility. Multiple contributions will be accepted with pleasure of course, while those who have not yet built something, naturally, cannot immediately contribute. Efforts are also being made to get entries from Digital employees. However, MUG non-members will not be allowed to call upon the MUG referral service.

Suggestions for improving the plan are solicited. If you like, write your suggestions on the back of the form along with any diagrams or other comments you want to submit for the file. At present, the plan is to send a copy of each applicable questionnaire to any MUG member who requests it, at the same time marking off the next block in the "times copied" column. Retyping or redrawing will be avoided both to avoid editing errors or distortion and to minimize time and cost; so please use a dark pen or pencil to insure readable copies. The "times copied" column, it is hoped, will be used at some future date to alert Digital to the need for formal applications notes and/or new products in areas where interest has proven to be high.

LAP6-1C
(MODIFICATION TO LAP6 OF M.A.W. CLARK)

Modification by: Dr. William H. Calvin
Departments of Neurological Surgery and
Physiology and Biophysics
University of Washington
Seattle, Washington

Two types of modifications have been made to the original LAP6 from St. Louis:

1. Conversions from LINC to LINC-8

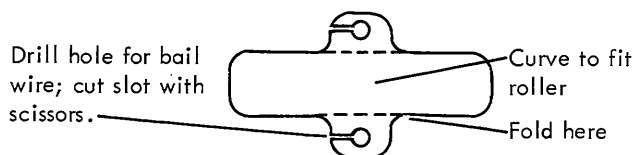
- a. Teletype through 0514 instruction.
- b. Display advance through CASE 1 and CASE 2, since CASE 0 and CASE 1 are awkward on Teletype keyboards.
- c. Mnemonics have been changed to correspond to new LINC-8 instructions
 - PDP 0513
 - TYP 0514
 - EXC 0740
 - SKP 0467

The old LINC-only instructions PIN and ENI have been eliminated, along with the mnemonic MTT.

- d. The index file protects PROGOFOP in BN 0-7.

2. Changes to Allow Use of Fan-Fold Paper in Teletype Printers

- a. Number of MS lines per page have been increased from 70 to 71 to give 11 inches per page.
- b. The META commands LI and PM now cause a KBDi pause prior to printing to allow the operator to align the fan-fold perforations with the top of the pages (except when one tries to LI a MS without a symbol table).
- c. We have devised some metal ears to be placed on the paper bail of the Teletype to keep the fan-fold perforation from buckling in front of the bail and jamming the Teletype. These may be made out of heavy shim steel with scissors. An outline for paper-doll artists is shown below. We currently use Moore form 9510 WF, which is 9.5 x 11" with holes down both sides which we tear off prior to use, giving 8.5 x 11" pages.



Modification Procedure for LAP6-1C

Each change is independent of the others, so one may change only the mnemonics or only the fan-fold paper, etc.

To change CASE 0, CASE 1 to CASE 1, CASE 2

RDC		
3/303		
	p.	CONT.
	1771	0244
	1772	0100
	1733	1437
	WRC	
	3/303	
	RDC	
	0/310	
	RDC	
	1/311	
	0316	6671
	0671	1460
	0672	0001
	0673	0220
	0674	6000
	WRC	
	0/310	
	WRC	
	1/311	

To Change to LINC-8 Teletype

RDC		
3/335		
1566	0341	
1567	0514	
1570	6000	
	WRC	
	3/335	
	RDC	
	0/300	
	0074	6076 (to avoid disturbing relay register)
	WRC	
	0/300	

To Change to LINC-8 Mnemonics TYP, SKP, PDP, EXC

RDC			
1/337			
0706	4343		
0745	0513	PDP	
0660	2630	EXC	1
0652	4646		
0716	4346		
0755	0467	SKP	
0704	4347		
0743	0514	TYP	
	WRC		
	1/337		

To Allow Use of Fan-Fold Paper (LINC or LINC-8)

```

RDC
3/335
1477 7706
WRC
3/335
-----
RDC
2/322
1001 7260
1260 0535
1261 0011
1262 6000
WRC
2/322
-----
RDC
2/227
RDC
3/335
1060 7775
1775 0535
1776 7422
1777 7061
WRC
2/227
WRC
3/335

```

For example, if your OPR 2 command serves to set and start an external clock, you might define 0502 as UPC for 'up counter'. Place 2650 in 0715 and 0502 in 0754. Similarly, if you have a buffered digital-to-analog converter and use OPR 6 to set it, you might define DTA as 0506 by placing 2427 in 0715 and 0506 in 0754.

To Protect PROGOFOP in Index

In virgin file, file any binary with SB PROGOFOP, 0. When filing is completed:

```

RDC
0/426
0016 0000 (first BN)
0017 0007 (number of BN to protect)
WRC
0/426

```

Comments on Further Modifications to Mnemonics

It is possible to add two additional mnemonics to LAP6 without major surgery.

LAP 6 uses only the first and last letter of the mnemonic, so make up your code so that it avoids any of the present first-last combinations. Insert the two LINC characters corresponding to these first-last letters in the spaces BBAA below in reversed order, i.e., last first and first last. For example, ADD would be entered as 2724, not 2427.

SKP and SNS originally both gave 0440. When SKP was changed to 0467 in the present -1C modification (by eliminating PIN), there were two locations containing 4646 (SS), both yielding 0440. The second is now available for a new mnemonic. Place BBAA (the last-first letter of the new mnemonic) in location 0715 of block 1/337 and the corresponding binary operation code in 0754.

The mnemonics RDC and MTP both presently give 0700. If you have no use for MTP, another space for a new mnemonic may be made. Place 2645 in 0657. Place the new mnemonic BBAA in 0725 and the corresponding operation code in 0764.

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Foxboro Company Limited, Canada

Prof. W. L. van der Poel
Technological University, Netherlands

R.E.C. White
University of Cambridge, England

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Westinghouse Electric Corporation

R. R. Wurzbarger
Motorola Incorporated

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Autoelectron, Inc.

PDP-8/I DELEGATES

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Liberty Gold Fruit Company, Inc.

Prof. E. Baumgartner
Universitat Basel, Switzerland

Aarne J. Valkama
Oy Nokia Ab Electronics Division
Finland

W. J. Whiten
University of Queensland, Australia

PDP-9 DELEGATES

Carroll L. Bartel
Wyle Laboratories

J. T. Bartlett
Dow Chemical Company

Dr. Z. S. Basinski
National Research Council of Canada

A. L. Boni
E. I. du Pont de Nemours

James Clarke
Sylvania Applied Research Laboratory

PDP-9 DELEGATES (Continued)

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Charles O. Drum
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Prof. E. Fiala
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John H. Findeis
TERC, Canada

D. M. Francis
Canada Centre for Inland Waters

Jay L. Frederick
Radio Corporation of America

Dennis R. Friedrichs
Battelle Northwest

B. R. Gaines
University of Essex, England

Robert A. Garvin
Champion Spark Plug Company

Dr. Marino Giannini
C.N.E.N., Italy

Jean-Claude Gouache
CERN/TC, Switzerland

R. A. Haase
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Dr. David L. Johnson
Louisiana Polytechnic Institute

Warren M. Kidd
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Brandt Kuperstock
Union Carbide Nuclear Division

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FOA 481, Sweden

N. Schuch
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Development Center

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Michael Rossin
On-Line Systems, Inc.

Arnold Wasserman
First National City Bank

Dr. Engelbert Ziegler
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West Germany

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Robert A. Ellis
Washington University

Dr. Graham Hoyle
University of Oregon

Dr. Edmund Jackson
Foundation for Scientific Relaxation, Inc.

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Max-Planck-Institut fur Hirnforschung
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Uppsala Universitet, Sweden

Gerald Johns
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Defence, Sweden

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University of Leeds, England

A. Daniel McDonald
Remington Arms Company, Inc.

Charles E. Molnar
Washington University

E. G. Murphy
United Kingdom Atomic Energy
Authority, England

Dr. Robert D. Sorkin
Purdue University

Paul F. Sullivan
NASA - Electronics Research Center

Leonard Zablow
College of Physicians and Surgeons

338 DISPLAY DELEGATE

Douglas V. Smith
General Electric TEMPO

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Laval University, Canada

J. R. Storey
Defence Research Board, Canada

Gordon Symonds
Department of Energy, Mines and
Resources, Canada

Thomas Taussig
Lawrence Radiation Laboratory
University of California

TIMES COPIED

INPUT TO COMPUTER	OUTPUT from COMPUTER	BETWEEN COMPUTERS	NOT COMPUTER INTERFACE
<input type="checkbox"/> PDP-5 <input type="checkbox"/> PDP-8 <input type="checkbox"/> PDP-8/S <input type="checkbox"/> PDP-8/1 <input type="checkbox"/> LINC-8	<input type="checkbox"/> PDP-1 <input type="checkbox"/> PDP-4 <input type="checkbox"/> PDP-7 <input type="checkbox"/> PDP-9	<input type="checkbox"/> PDP-6 <input type="checkbox"/> PDP-10 <input type="checkbox"/> OTHER: _____	<input type="checkbox"/> DATA FORMAT OR CODE CONVERTER <input type="checkbox"/> CONTROL SYSTEM <input type="checkbox"/> SIGNAL GENERATOR <input type="checkbox"/> SPECIAL COMPUTER <input type="checkbox"/> OTHER -use reverse side

DATA INPUT, OUTPUT

D-A, _____ BITS, _____ μ s/conv. TYPE _____

A-D, _____ BITS, _____ μ s/conv. TYPE _____

MAG. TAPE INCREMENTAL, _____ BITS/INCH TYPE _____

PAPER TAPE READER _____ Char./sec. TYPE _____

PAPER TAPE PUNCH _____ Char. sec. TYPE _____

CARD READER, _____ Cards/min. TYPE _____

CARD PUNCH, _____ Cards/min. TYPE _____

REAL TIME CLOCK BCD _____ BINARY _____

HIGHSPEED DATA CHANNEL _____ μ s/word _____

MULTIPLE TELETYPES TYPE _____ QUANTITY _____

OTHER -use reverse side: _____

MEMORY DEVICES

MAG TAPE _____ B/IN: IBM FORMAT? _____ TYPE _____

DRUM MEMORY _____ WORDS _____ BITS/WORD TYPE _____

DISC MEMORY _____ WORDS _____ BITS/WORD TYPE _____

CORE MEMORY _____ WORDS _____ BITS/WORD TYPE _____

OTHER -use reverse side _____

DISPLAY

'SCOPE CHAR GEN? _____ LT. PEN? _____ MEM? _____ TYPE _____

PLOTTER, _____ POINTS/SEC TYPE _____

PRINTER, _____ LINES/MIN TYPE _____

SUPERVISORY PANEL, _____ LAMPS, FOR _____ PROCESS

OTHER - use reverse side _____

SCIENTIFIC INSTRUMENTS

XRAY ANALYZER TYPE _____

CHROMATOGRAPH: GAS _____ LIQUID _____ TYPE _____

SPECTROMETER: IR _____ VIS _____ UV _____ TYPE _____

PULSE HEIGHT ANALYZER TYPE _____

PARTICLE CHAMBER CLOUD _____ BUBBLE _____ SPARK _____

MICRODENSITOMETER, TYPE _____

OTHER - use reverse side _____

MISCELLANEOUS CONTROLS

TESTER FOR _____ TYPE _____

SINGLE AXIS MOTION, _____ STEPS/SEC TYPE _____

TWO AXIS MOTION, _____ STEPS/SEC TYPE _____

THREE AXIS MOTION, _____ STEPS/SEC TYPE _____

OTHER - use reverse side _____

<input type="checkbox"/> M SERIES	YEAR(S)	NAME _____	AREA CODE _____
<input type="checkbox"/> K SERIES	SYSTEM	TITLE _____	'PHONE _____
<input type="checkbox"/> A SERIES	BUILT:	AFFILIATION _____	
<input type="checkbox"/> R-W SERIES	'60 '64 '68	ADDRESS _____	
<input type="checkbox"/> 4000 SERIES	'61 '65 '69	CITY _____	STATE _____ ZIP _____
<input type="checkbox"/> _____	'62 '66 '70	PREFER TO CONSULT BY <input type="checkbox"/> LETTER <input type="checkbox"/> 'PHONE	
<input type="checkbox"/> _____	'63 '67 '71	DECUS/MUG APPLICATIONS EXCHANGE CLASSIFIER	

BACK USED

DIGITAL SOFTWARE NEWS

This newsletter is intended for PDP-5, 8, 8/S, 7, 9, and LINC-8 users. It is compiled and published by the Software Maintenance Group and contains information about the following.

1. **Software Problems and Corrections:** Various problems with Digital's standard library programs and manuals are discussed and solutions given. In cases where no corrections are available at the time of publication, they will be included in a later newsletter.
2. **Programming Notes:** Various programming aids are discussed, generally in response to customer questions. An attempt is made to supplement the manuals where necessary. Suggestions for the subject material of these notes should be directed to the Software Maintenance Group (address below).
3. A list and brief description of new and/or revised software which is available from the Program Library.

The Software Maintenance Group is responsible for the maintenance of Digital's standard library programs. There is a software support person at most of the regional and district sales offices and initial reports should be made to them. In cases where they are unavailable, reports should be directed to:

Software Maintenance Group
Digital Equipment Corporation
146 Main Street
Building 3-3
Maynard, Massachusetts 01754

It is strongly suggested that all problems referred to this group be sent on Software Trouble Report Forms, which are available from the Program Library (address below). For more efficient service, the following information should be included.

1. Type and configuration of machine.
2. A brief but concise description of the problem. Include the name and date of the Digital library program in use at the time of problem.
3. Listing of user program in use at time of problem.
4. Listing of erroneous results and/or error messages.
5. Contents of AC and PC where applicable.

New and revised software, manuals, and Software Trouble Report forms are available from the Program Library. When ordering, include the document number and a brief description of the program or manual desired. At this time there is no automatic updating of revised programs and manuals. They will be shipped only on request. Revisions and notifications of updates will be published in this newsletter, which will continue to be part of DECUSCOPE. Direct all inquiries and requests to:

Program Library
Digital Equipment Corporation
146 Main Street
Building 3-3
Maynard, Massachusetts 01754

I. PDP-5, 8, 8/S

A. PROGRAMMING PROBLEMS

PROGRAM: PDP-8 DISK/DECTAPE KEYBOARD MONITOR (DEC-08-SBAB)

PROBLEM: This version of the Monitor will not operate properly with more than one disk.

SOLUTION: If the hardware configuration consists of a DF32 and one or more DF32s, the MULTIPLE DISK OVERLAY should be used with the builder. This overlay is available from the Program Library as DEC-D8-SBBA. The document which accompanies it gives full directions on its use.

PROGRAM: EDITOR (DEC-08-ESAB)

PROBLEM: The current version of the Editor will not automatically suppress input to avoid a buffer overflow. The buffer, which can accommodate 6000₁₀ characters (70 heavily commented lines, 340 non-commented lines), can be exceeded by the use of any one of four commands: SEARCH, CHANGE, APPEND and INSERT. When the buffer limits are reached, the bell is rung once for every two characters which are added. If overflow is allowed to continue, the buffer can expand to destroy the Binary Loader, wrap around core and destroy the Editor.

SOLUTION: The user should terminate input at the next carriage return following the first ringing of the bell.

PROGRAM: CALCULATOR (DEC-08-UDCA)

PROBLEM: Unary minus is treated as an arithmetic minus. An example is $-5+1$, which is evaluated as $-(5+1)=-6$, rather than $(-5)+1=-4$ as it should be.

SOLUTION: The use of parenthesis will correct the problem. Example: $(-5)+1$ will return the correct result.

B. PROGRAMMING NOTES

FORTRAN II: SAVING CORE

Each constant which appears on the right side of an equal sign is assigned to a unique core location (3 words for each floating point constant). In the following example, there is a significant waste of core, as the constants are all the same.

```
A(I)=0.  
B(I)=0.  
C(I)=0.  
D(I)=0.
```

Eight words can be saved and the same results achieved by the following code:

```
ZERO=0  
A(I)=ZERO  
B(I)=ZERO  
C(I)=ZERO  
D(I)=ZERO
```

C. NEW AND REVISED SOFTWARE

1. NEW

FOCAL (DEC-08-AJAA)

A new conversational language has been added to the Library of the PDP-8 family of computers. FOCAL (FOrmula CALCulator) is an on-line, conversational, utility program designed to help scientists, engineers, and students solve numerical problems of any level of complexity. The language consists of short imperative English statements which are easily learned. Mathematical expressions are typed in standard notation; hence no previous programming experience is needed to make FOCAL one of the most

useful tools in the office or lab. The binary tape is available from the Program Library on request as DEC-08-AJAA-PB. The manual which accompanies it is DEC-08-AJAA-D. FOCAL is a chargeable item. (See price list included in this newsletter.)

2. REVISED

Double Precision Sine Subroutine DEC-08-(FMFB-PA) as described in the Math Library Manual (DEC-08-FFAC-D) has been revised to correct for a problem of overflow which occurred when using very small numbers as input to the routine. Since some of the addresses in this subroutine are referenced by other routines, two constants were also moved so that the additional instruction needed to correct the error would not disturb any addresses known to other routines.

The subroutine is distributed as an ASCII paper tape on request from the Program Library as DEC-08-FMFB-PA with the documentation contained in the Math Library Manual (DEC-08-FFAC-D).

Calculator-8 DEC-08-UDCA (formerly Digital 8-10-S)

The calculator uses logs in calculating requested powers of numbers. The 8-10-S version checks to see if the requested power is zero (0) and if so, outputs a one (1) as the result, since any number to the zero power is 1. This is correct for all cases except zero to a power which is undefined. The revised version has added one more check to take care of this special case of zero to a power. If it finds the number being exponentiated to be zero, it bypasses the calculation and gives zero as the result.

3. NEW MAINDECS (Tapes and write-ups)

MAINDEC-8I-DOIA	Instruction Test I
MAINDEC-8I-DO2A	Instruction Test II
MAINDEC-08-DOAA	Extended Arithmetic Instruction Test
MAINDEC-08-DIEA	PDP-8, 8I Extended Memory Test

4. REVISED MAINDECS

MAINDEC-08-D02B	Instruction Test 2B Replaces MAINDEC-08-D02A
MAINDEC-08-D04B	Random JMP TEST Replaces MAINDEC-08-D04A
MAINDEC-08-D05B	Random JMP-JMS Test Replaces MAINDEC-08-D05A
MAINDEC-08-D07B	Random ISZ Test Replaces MAINDEC-08-D07A
MAINDEC-08-D1J0	Memory Check Replaces MAINDEC-08-802
MAINDEC-08-D2PA	Reader Test Replaces MAINDEC-08-D2AA and MAINDEC-08-D2BA
MAINDEC-08-D2RA	Keyboard Replaces MAINDEC-08-D2DA
MAINDEC-08-D2SA	Printer Test Replaces MAINDEC-08-D2DA
MAINDEC-08-D2TA	Reader, Printer, Punch Replaces MAINDEC-08-D2AA MAINDEC-08-D2BA MAINDEC-08-D2CA
MAINDEC-08-D1AB	Memory Power ON/OFF TEST Re- places MAINDEC-08-D1AA
MAINDEC-08-D81B	DB08A Test Replaces MAINDEC-08-D81A

D. PDP-8, 8/I PRICE LIST

The following is a list of the PDP-8, 8/I, 8/S software currently available from the Program Library, along with the charge for each item. Listings marked with a + are included in the corresponding document.

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
Digital-F-85/S PDP-8/S Users Handbook	5.00			
DEC-08-NGCB PDP-8 Console Manual	2.00		N/A	N/A
DEC-08-LRAA RIM Loader	1.00	†	1.00	3.50
DEC-08-PMPA RIM Punch 33-75	1.00	†	1.00 each (4 ea.)	3.50
DEC-08-LBAA Binary Loader (33, 750, 183)	1.00	†	1.00	3.50
Digital-8-5-U Binary Punch Routine (33 ASR)	1.00	†	1.00	N/A
Digital-8-5-U Binary Punch Routine 75A	Combined in Bin Punch (33 ASR)	†	1.00	N/A
Digital-8-6-U Octal Memory Dump	1.00	†	N/A	1.00
DEC-08-LHAA "HELP" Loader	1.00	†	(2) 1.00 for both	3.50
Digital-8-16-S Master Tape Duplicator	1.00	†	2.50	N/A
DEC-08-UDCA Desk Calculator-8	1.00	†	2.50	3.50
DEC-08-AFAC FORTRAN	2.00			
	AFC1 Compiler	3.00	2.50	14.00
	AFC2 Symbol Print		1.00	3.50
	AFC3 Op. System	3.00	2.50	21.00
	Sample Program		N/A	1.00
DEC-08-AJAB FOCAL	1.00		2.50	20.00
DEC-08-ASAB PAL III	2.00			
	ASB1 PAL III Binary		1.00	17.50
	ASB2 Extended Symbols		N/A	3.50
DEC-08-CDDA .DDT	2.00		1.00	14.00
DEC-08-CMAA MACRO-8	2.00	3.00	Hi 2.50 Low 2.50	Hi 14.00 Low 14.00
DEC-08-COC0 ODT-8	1.00		Hi 1.00 Low 1.00	Hi* 3.50 Low* 3.50
DEC-08-ESAB Symbolic Editor	2.00	3.00	1.00	3.50

* Same except for origins.

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
DEC-D8-SDAA Disk Monitor System	2.75			
DEC-D8-SBAC PDP-8 Disk System Builder	Re: D8-SDAA	3.00	Re: D8-SDAA	N/A
DEC-D8-AFAO DISK FORTRAN Compiler and Operating System	Re: D8-SDAA	6.00	Re: D8-SDAA	N/A
DEC-D8-ASAA Disk Assembler PAL-D	1.00	3.00	Re: D8-SDAA	N/A
DEC-D8-CDD0 DISK DDT-8	Re: D8-SDAA	N/A	Re: D8-SDAA	N/A
DEC-D8-ESAB DISK EDITOR	Re: D8-SDAA	3.00	Re: D8-SDAA	N/A
DEC-D8-PDAA DISK PIP	Re: D8-SDAA	N/A	Re: D8-SDAA	N/A
DEC-08-SUB0 DECTape Programming Manual	2.00	3.00	30.00 DECTape	17.00
Digital-8-3-U DECTape Library System Loader	1.00	†	1.00	N/A
DEC-08-EUFA TC01 DECTape Formatter	1.00	†	1.00	10.50
DEC-08-LUAA TC01 Bootstrap Loader	1.00	†	1.00	3.50
DEC-08-FUB0 TC01 DECTape Subroutines	1.00	†	N/A	3.50
DEC-08-FFAC Program Library Math Routines	2.00			
FMAA-PA Single Precision Square Root Routine	Re: 08-FFAC	†	N/A	1.00
FMBA-PA Single Precision Signed Multiply Subroutine	Re: 08-FFAC	†	N/A	1.00
FMCA-PA Single Precision Signed Divide Subroutine	Re: 08-FFAC	†	N/A	1.00
FMDA-PA Double Precision Signed Multiply Subroutine	Re: 08-FFAC	†	N/A	1.00
FMEA-PA Double Precision Signed Divide Subroutine	Re: 08-FFAC	†	N/A	1.00
FMFB-PA Double Precision Sine Routine	Re: 08-FFAC	†	N/A	1.00
FMGA-PA Double Precision Cosine Routine	Re: 08-FFAC	†	N/A	2.50
FMHA-PB Four Word Floating Point Package	Re: 08-FFAC	†	1.00	
FMIA-PA Logical Subroutines	Re: 08-FFAC	†		1.00
FMJA-PA Arithmetic Shift Routines	Re: 08-FFAC	†		1.00
FMKA-PA Logical Shift Subroutines	Re: 08-FFAC	†		1.00

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
Digital-8-18-U Alphanumeric Message Typeout	1.00	†	N/A	1.00
Digital-8-19-U Teletype Output Package	1.00	†	N/A	1.00
Digital-8-20-U Character String Typeout	1.00	†	N/A	1.00
Digital-8-21-U Symbolic Tape Format Generator	1.00	†	1.00	N/A
Digital-8-22-U Unsigned Decimal Print	1.00	†	N/A	1.00
Digital-8-23-U Signed Decimal Print, Single Precision	1.00	†	N/A	1.00
Digital-8-24-U Unsigned Decimal Print, Double Precision	1.00	†	N/A	1.00
Digital-8-25-U Signed Decimal Print, Double Precision	1.00	†	N/A	1.00
Digital-8-17-U EAE Inst. Set Simulator (Type 182)	1.00	†	N/A	1.00
Digital-8-21-F Singled Mult. Single Precision (EAE Type 182)	1.00	†	N/A	1.00
Digital-8-22-F Signed Div. Single Precision (EAE Type 182)	1.00	†	N/A	1.00
Digital-8-23-F Signed Mult. Double Precision (EAE Type 182)	1.00	†	N/A	1.00
Digital-8-25-F Floating Point (EAE Type 182)	1.00	†	A 1.00 B 1.00 C 1.00 D 2.50	A 3.50 B 3.50 C 3.50 D 3.50
Digital-8-5-S Floating Point Package	2.00	†	1.00 ea. (4)	17.50
Digital-8-10-U BCD to Binary Conversion	1.00	†	N/A	1.00
Digital-8-11-U Double Precision BCD to Binary Conversion	1.00	†	N/A	1.00
Digital-8-14-U Binary to Binary Coded Decimal Conversion	1.00	†	N/A	1.00
Digital-8-15-U Binary to Binary Coded Decimal Conversion (4 digit)	1.00	†	N/A	1.00
Digital-8-28-U Single Precision Decimal to Binary Conversion	1.00	†	N/A	1.00
Digital-8-29-U Double Precision Decimal to Binary Conversion	1.00	†	N/A	2.50
Digital-8-33-U 5/8 TOG (552)	1.00	†	1.00	7.00
Digital-8-34-U DECEx DECtape Exerciser (552)	1.00	†	1.00	14.00
Digital-8-35-S-A TTY 680 5-Bit Char. Assembly Routines	1.00	†	N/A	3.50

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
Digital-8-35-S-B TTY 680 8-Bit Char. Assembly Routines	1.00	†		3.50
Digital-5-48-M Type 34 D Display Test	1.00	†	1.00	3.50
Digital-8-12-U Incremental Plotter Subroutines	1.00	†	N/A	1.00
Digital-8-15-S Oceanographic Analysis	3.00	†	2.50	N/A
DEC-08-G61D Prog'ed Buffered Disp. 338 Prog. Man.	2.00	†	N/A	N/A
DEC-08-AEAA Pal III Def. for 338	1.00	†	1.00	3.50
DEC-08-USB0 Multianalyzer Prog. - Pulse Ht. Analysis	2.00	†	1.00 ea. (3)	3.50 ea. (3)

All MAINDEC writeups, which include listings, can be purchased for \$1.00 each.

MAINDEC-08-D5DA DF32 Multi Disk	1.00		1.00	3.50
MAINDEC-08-D601 338 Instruction Test	1.00		2.50	20.00
MAINDEC-08-D60B 338 Visual Buffered Display	1.00		2.50	14.00
MAINDEC-08-D61A Lots of Little Pictures for an Eight	1.00		1.00	3.50
MAINDEC-08-D6CB Calcomp Plotter Test	1.00		1.00	7.00
MAINDEC-08-D6EA POP Test	1.00		1.00	3.50
MAINDEC-08-D6FA P Jump	1.00		1.00	3.50
MAINDEC-08-D6GA A/D Calibration Check	1.00		1.00	3.50
MAINDEC-08-D6HA AF04A Diagnostic and Demonstration	1.00		1.00	3.50
MAINDEC-08-D6IA VF38 - Search Mode Test	1.00		1.00	7.00
MAINDEC-08-D6SA A/D Calibration Check for SD1		Not available at this time		
MAINDEC-08-D7BA Exerciser for PDP 8/KDF-9 Inter.		Not available at this time		
MAINDEC-08-D8AA 196 Intercommunication Buffer	1.00		(5) 1.00	20.00
MAINDEC-08-D8BA 338 Push Button Test	1.00		1.00	3.50
MAINDEC-08-D8CA Data Test for 636B	1.00	Communication Interface	1.00	3.50
MAINDEC-08-D8CJ IOT Test for 636B	1.00	Communication Interface	1.00	3.50

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
MAINDEC-08-D8DA 338 Character Generator Test	1.00		1.00	3.50
MAINDEC-08-D8EA DP01A - IOT and Data Tests	1.00		1.00	3.50
MAINDEC-08-D8FA IOT and Data Test for 637 Data Tel.	1.00		1.00	7.00
MAINDEC-08-D8GA DB 88 Test	1.00		2.50	3.50
MAINDEC-08-D8IA DB08A - GO/NOGO Test	1.00		1.00	3.50
MAINDEC-08-D8KA DP01A and Data Test (60-67)	Not available at this time.			
MAINDEC-08-D9AA-D (L) TC58 Data Test	1.00		2.50	15.00
MAINDEC-08-D9BA-DL TC58 Drive Function Timer	1.00		1.00	3.50
MAINDEC-08-D9CA TC 58 Random Exerciser	1.00		2.50	8.75
MAINDEC-08-D2EA High Speed Reader Test	1.00		1.00	3.50
MAINDEC-08-D2FC PDR-8 High Speed Reader Test	1.00		1.00	7.00
MAINDEC-08-D2GA High Speed Punch Test	1.00		1.00	7.00
MAINDEC-08-D2GO Reader Test Tapes			1.00	3.50
MAINDEC-08-D2G1 All Zeros Test Tape			2.50	N/A
MAINDEC-08-D2G2 Ones and Zeros Test Tape			2.50	N/A
MAINDEC-08-D2G3 Binary Count Pattern Test Tape			2.50	N/A
MAINDEC-08-D2HA Typesetting Paper Tape Reader	1.00		1.00	7.00
MAINDEC-08-D2LA 645 A Line Printer	1.00		1.00	3.50
MAINDEC-08-D2MA Monroe Printer Test	1.00		1.00	3.50
MAINDEC-08-D2NB CR01C NCR Card Reader Test	1.00		1.00	3.50
MAINDEC-08-D2PB-D(L) family of 8 ASR 33/35 Reader Test	1.00		1.00	7.00
MAINDEC-08-D2QB-D(L) family of 8 ASR 33/35 Punch Test	1.00		1.00	7.00
MAINDEC-08-D2RB-D(L) family of 8 ASR 33/35 Keyboard Test	1.00		1.00	3.50
MAINDEC-08-D2SB-D(L) family of 8 ASR 33/35 Printer Test	1.00		1.00	7.00
MAINDEC-08-D2TC-D(L) family of 8 ASR 33/35 Reader, Printer, Punch Test	1.00		1.00	3.50
MAINDEC-08-D3BB TC01 Basic Exerciser	1.00		2.50	17.50

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
MAINDEC-08-D3EB TC01 Extended Memory Exerciser	1.00		1.00	3.50
MAINDEC-08-D3RA TC01 DECTREX1 (DECTape Random Exer. 1)	1.00		2.50	8.75
MAINDEC-08-D4AA PDP-8/8I Basic Parity Checkerboard	1.00		2.50	10.50
MAINDEC-08-D4BA PDP-8/8I Extended Parity Checkerboard	Not Available at this time			
MAINDEC-08-D5AA RM08 Drum Test	1.00		1.00	3.50
MAINDEC-08-D5BB DF32 Diskless-Logic Test, Mini Disk	1.00		1.00	17.50
MAINDEC-08-D5CA DF32 Disk Data Mini Disk Test	1.00		2.50	14.00
MAINDEC-08-D01A Instruction Test Part 2A	1.00		2.50	N/A
MAINDEC-08-D02B PDP-8 Instruction Test Pt. 2B	1.00		1.00	3.50
MAINDEC-08-D04B Random JMP Test	1.00		1.00	3.50
MAINDEC-08-D05B Random JMP-JMS Test	1.00		1.00	3.50
MAINDEC-08-D07B Random ISZ Test	1.00		1.00	3.50
MAINDEC-08-DOAA EAE Test	1.00		1.00	3.50
MAINDEC-827 580 Maintenance Comp. and Subroutines	1.00		3.50	7.00
MAINDEC-828 LT08 Teleprinter Test	1.00		1.00	3.50
MAINDEC-831 5/8 DECTape Maintenance Pk. (552)	1.00		1.00	7.00
MAINDEC-839 Parity Option Test	1.00		1.00	3.50
MAINDEC-843 Type 30 N, G Display Exerciser	1.00		1.00	3.50
MAINDEC-844 Monroe Printer Test	1.00		1.00	N/A
MAINDEC-8I-DO1B Instruction Test 1	1.00		2.50	17.50
MAINDEC-8I-DO2B Instruction Test 2	1.00		1.00	10.50
MAINDEC-8S-DO1A Instruction Test 1	1.00		2.50	17.50
MAINDEC-8S-DO2A Instruction Test 2	1.00		2.50	10.50
MAINDEC-8S-D03A Basic JMP-JMS Test	1.00		1.00	7.00
MAINDEC-8S-D04A Random JMP Test	1.00		1.00	3.50
MAINDEC-8S-D05B Random JMP-JMS Test	1.00		1.00	3.50

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
MAINDEC-8S-D06A Random DCA Test	1.00		1.00	3.50
MAINDEC-8S-D07A Random ISZ Test	1.00		1.00	3.50
MAINDEC-8S-D11A 4K Memory Address Test	1.00		(2) 1.00	(2) 3.50
	1.00		(2) 1.00	(2) 3.50
MAINDEC-08-D0BA EAE Test	1.00		1.00	3.50
MAINDEC-08-D0RA Automatic Recovery Option Diagnostic	1.00		1.00	3.50
MAINDEC-08-D1AB PDP-8 Memory Power On/Off Test	1.00		1.00	3.50
MAINDEC-08-D1B0 Memory Address Test	1.00		(2) 1.00	D1B1 3.50 D1B2 3.50
MAINDEC-08-D1EA PDP-8/8I Extended Memory Checkboard Test	1.00		1.00	3.50
MAINDEC-08-D1GA PDP-8/8I Ext. Memory Control	1.00		1.00	3.50
MAINDEC-08-D1HA PDP-8/8I Extended Memory Address Test	1.00		1.00	7.00
MAINDEC-08-D1JO-L Basic Checkerboard	1.00			
		D1J1 (low) Mem. Chkbd.	1.00	7.00
		D1J2 Chkbd. Hi	1.00	3.50
MAINDEC-801-1 Basic Instruction Test	1.00		1.00	N/A
MAINDEC-825 680 Static Test	1.00		1.00	7.00
MAINDEC-826-A 680 8-Bit Character Exerciser	1.00		1.00	7.00
MAINDEC-826-B 680 5-Bit Character Exerciser	1.00		1.00	7.00
MAINDEC-8S-D15A 4K Sense Amplifier Test	1.00		1.00	3.50
MAINDEC-8S-D5BB DF32 Diskless-Logic Test, Mini Disk	1.00		1.00	17.50
MAINDEC-8S-D6AA CALCOMP Plotter Test	1.00		1.00	3.50
MAINDEC-8S-D8AA KW08 Check	1.00		1.00	3.50
MAINDEC-8S-D8BA Data Break Test 1	1.00		1.00	7.00
MAINDEC-8S-D8CA Data Break Test 2	1.00		1.00	3.50
MAINDEC-8S-D23B High Speed Reader Test	1.00		1.00	7.50

II. LINC-8

A. PROGRAMMING PROBLEMS

PROGRAM: PROGOFOP (DEC-L8-SFA0-D)

PROBLEM: Reversed Descriptions on P 10 and 11 of Document

SOLUTION: The description of the Soroban Keyboard Interface which appears on page 10, refers to the listing which appears on page 11 and begins with the comment /IOT INSTRUCTIONS. Similarly the description for Optional Magnetic Tapes which appears on page 11, refers to the listing which appears on page 10.

PROBLEM: Error in code of page 10 causing selection of LINCtape units 2 and 3 to be irreversible.

SOLUTION: Line 13 of the listing currently reads:

```
CLL RAL /3 IN AC
It should read:
RAL /3 IN AC
```

The assembly code to the left of the symbolic is also in error from line 12 - line 25 due to the fact that there are no carriage returns after the origins on lines 12 and 17. It should read as follows:

11		0120
12	0120	7201
13	0121	7004
14	0122	4731
15	0123	5727
16		0124
17	0124	7201
18	0125	4730
19	0126	5727
20		
21		
22		
23	0127	1010
24	0130	0544
25	0131	0600

PROGRAM: QUESTION AND ANSWER SUBROUTINE (Q and A)

PROBLEM: If the Q and A subroutine is used with a manuscript generated by the LAP6 assembler using the text facility, the decimal point (period) will not display.

SOLUTION: The reason for this is that LAP6 assigns a value of 64 to that character and Q and A does not recognize it. The problem is easily solved by inserting the two display pattern words for period into the Q and A Subroutine as follows: location contents

1350	0001
1351	0000

B. NEW SOFTWARE

LAP6-3L (DEC-L8-MAAC)

LAP6-3L is the LINC-8 version of an on-line programming system which uses the Teletype and scope for communication with the user and LINCtape for storage and additional working area. It is a combination Monitor, Editor and Assembler which is easy to work with and much faster than previous LINC-8 assembly systems due to the greatly reduced amount of tape shuffling.

It is available on request from the Program Library.

III. PDP-7/9

A. PDP-7/9 BASIC PROGRAMMING PROBLEMS

PROGRAM: FORTRAN II

PROBLEM: Mathematical expressions such as $-HD \uparrow 2$, where HD

is any real argument, are interpreted and executed as negative arguments raised to a power of 2. The result then becomes positive.

SOLUTION: To have the minus sign interpreted as an arithmetic subtraction, one must use parenthesis to separate the minus sign and the algebraic expression, e.g., $-(HD \uparrow 2)$. In this case, whether HD is positive or negative, the result is always positive and is subtracted from the expression or value preceding $-(HD \uparrow 2)$.

Examples:

TA = $-(HD \uparrow 2)$ the expression inside the parenthesis returns a positive result. TA is then negative because of the minus sign which precedes the algebraic expression.

If HD is positive then $-HD$ is negative and $-HD \uparrow 2$ is positive.

If HD is negative then $-HD$ is positive and $-HD \uparrow 2$ is positive again.

PROGRAM: FORTRAN II I/O LIBRARY

PROBLEM: Since a new modification has been made to PDP-9 high speed paper tape readers, the current library version of the FORTRAN II I/O library cannot be read without producing a checksum error. This error does not prevent proper execution of any FORTRAN II program.

SOLUTION: To correct this error, a new binary version of the I/O Library tape, DEC-9B-AFE5-PU Rev. 2/2/68, has replaced the version dated Rev. 3/28/67 and is available from the Program Library.

PROGRAM: FLOATING POINT PACKAGE

PROBLEM: The current version of the Floating Point Package can be assembled only with PDP-7/9 Basic Assembler, with two undefined symbols: QUO and ACASE. These two symbols are assigned proper core locations at the end of the assembly and do not prohibit the proper execution of the package.

If an attempt is made to assemble the Floating Point Package with the Extended Assembler, one additional error message is outputted.

RDA previous value DIV new value

which indicates that a permanent symbol was used as a tag and was not redefined. In this case, the Floating Point Package will not assemble and run properly.

SOLUTION: The revised version allows the flexibility of assembly by either the PDP-7/9 Basic or Extended Assembler.

The changes that affect the revised version are:

OLD	NEW
QUO	QUO#
ACASE	ACASE#
DIV	DIVID

NOTE: when the exponent is zero, the package occasionally puts a minus sign in front of the zero exponent. The results are unaffected by the minus.

PROGRAM: RIM LOADER

PROBLEM: The RIM Loader is destroyed by the Advanced Software.

SOLUTION: It was not anticipated that both the Basic and Advanced Software would be used together. If the Advanced Software is being used, there is no need for the RIM Loader and the core locations are used by the Advanced Software.

B. PDP-9 ADVANCED SOFTWARE PROGRAMMING PROBLEMS

PROGRAM: LINKING LOADER

PROBLEM: Either in the I/O or Keyboard Monitor environment, the Linking Loader cannot be restarted if an error has caused the termination of the loading process.

SOLUTION: There is NO way to restart the Linking Loader other than reloading the Linking Loader.

PROGRAM: KEYBOARD MONITOR

PROBLEM: The software has trouble finding specified blocks on a DECTape (several passes must be made over the same area of the tape) due to old DECTapes or hardware work which has been done on the DECTape units.

SOLUTION: This normally is an indication that the DECTape needs to be reformatted or the starting delay in the control logic is too long and should be adjusted.

PROGRAM: I/O MONITOR

PROBLEM: Some difficulty has been experienced as to determining which Keyboard Monitor commands can be used or applied with the I/O Monitor (paper tape) System.

SOLUTION: The answer is none of them, since the I/O Monitor, which occupies the first 775₁₀ locations, is a part of each system program tape and simply provides the linkage between the program and I/O device handlers.

C. PROGRAMMING NOTES

Restarting systems programs in the I/O Monitor environment.

SYSTEM RESTART can be used to attempt to restart a system program (excluding DDT and the Loader) which has halted during operation. It is most conveniently used if the symbolic program of SYSTEM RESTART has been punched onto tape and assembled by MACRO-9. If this has been done and a binary tape is available, proceed as follows:

1. place the binary tape in the reader
2. push the tape feed control to clear the end-of-tape flag
3. set address switches to 17720
4. press I/O RESET

5. press READIN

If a binary tape is not available, SYSTEM RESTART may be entered through the AC switches, using the deposit key. When this has been done, proceed as follows:

1. set address switches to 17720
2. press I/O RESET
3. press START

If the restart attempt is successful, the effect will be the same as a control P (↑P) restart. Further restarts are possible without re-loading SYSTEM RESTART by the following procedure:

1. set address switches to 17720
2. press I/O RESET
3. press START

If the restart attempts fails, it will be necessary to reload the system program tape.

Since a halt usually indicates a rather serious problem, SYSTEM RESTART may fail to restart the program.

Two instances in which it will work:

1. When the user has accidentally typed an ALT Mode instead of a carriage return as a command string terminator, and wishes to regain the program for another run.
2. After an IOPS 3 error if the offending device flag has been removed.

			.TITLE SYSTEM RESTART
			.FULL
			.LOC 17720
17720			EEM
17720	707702	D	LAC* E
17721	237734		DAC A
17722	057731		CAF
17723	703302		ION
17724	70042		LAC* B
17725	237732		ISA
17726	705504		DZM* C
17727	177733		JMP* A
17730	637731		0
17731	000000	A	6
17732	000006	B	1413
17733	001413	C	632
17734	000632	E	END D
	017720		

E. PDP-9 PRICE LIST

The following is a list of the software currently available from the PDP-9 Program Library, along with the charge for each item. Items marked with a † are available only as part of the Basic Mod Kit. Items marked with an * are available in a package (MAINDEC writeups and listings or binaries) or separately.

MANUALS

DIGITAL-F-95 User Handbook	5.00
DEC-9A-AFAB-D FORTRAN IV Manual	2.00
DEC-9A-AM9B-D MACRO-9 Manual	2.00
DEC-9A-GUAB-D Utility Manual	4.50
DEC-9A-MABO-D MONITOR Manual	2.00
DEC-9A-NGBA-D Keyboard Monitor Guide	2.00
DEC-9A-NGAA-D I/O Monitor Guide	.50

SOFTWARE PACKAGES

Advanced Software System Paper Tapes (binary)	30.00
Basic MAINDEC Writeups and listings (contents marked*)	20.00
Basic MAINDEC: Binary paper tapes (contents marked*)	30.00
BASIC SYSTEM Binary paper tapes (contents marked†)	30.00
BASIC MOD KIT: Listing and sources (contents marked†)	55.00

<u>ADVANCED: Keyboard Monitor</u>	<u>Document</u>	<u>List</u>	<u>Binary</u>	<u>ASCII</u>
DEC-9U-SLB1 8K Advanced DECtape System			DECtape 30.00	
DEC-9U-SLB2 16K Advanced DECtape System			DECtape 30.00	
(SLB1 and SLB2 contain the Linking Loader, DDT, KM9, the System Generator, UPDATE, .SYSLD, EDIT, PIP, F4, MACRO, DUMP, CONV, .LIBR, REAL NON, and INTEGE NON)				
DEC-9U-EUMA MONITO	1.00		1.00	
DEC-9U-EUSA SYSTEM	1.00		1.00	
DEC-9U-LBAA PDP-9 DECtape System Bootstrap Loader			1.00	

<u>ADVANCED: I/O Monitor</u>	<u>Document</u>	<u>List</u>	<u>Binary</u>	<u>ASCII</u>
DEC-9T-AFA1 FORTRAN IV Compiler	Re: DEC-9A AF40	Re: 9U-SPA1	5.00	75.00
DEC-9T-ALAA Library System Part 1 of 3	Re: DEC-9A AF40	Re: 9U-SPA1	2.50	60.00
DEC-9T-ALBA Library System Part 2 of 3	Re: DEC-9A AF40	Re: 9U-SPA1	2.50	60.00
DEC-9T-ALCA Library System Part 3 of 3	Re: DEC-9A AF40	Re: 9U-SPA1	2.50	60.00
DEC-9T-ALEA End of File	Re: DEC-9A AF40		1.00	N/A
DEC-9T-AMA1 MACRO 9 Assembler	Re: DEC-9A AM9A	Re: 9U-SPA2	5.00	30.00
DEC-9T-CDA1 DDT w/o Patch	Re: DEC-9A GUAB	Re: 9U-SPA2	2.50	15.00
DEC-9T-CDF1 DDT w Patch	Re: DEC-9A GUAB	Re: 9U-SPA2	2.50	15.00
DEC-9T-EEA1 Editor	Re: DEC-9A GUAB	Re: 9U-SPA2	2.50	15.00
DEC-9T-LLA1 Linking Loader	Re: DEC-9A GUAB	Re: 9U-SPA2	2.50	15.00
DEC-9T-PCA1 7-9 Converter	Re: DEC-9A GUAB	Re: 9U-SPA2	2.50	15.00
DEC-9T-PPA1 PIP	Re: DEC-9A GUAB	Re: 9U-SPA2	2.50	15.00
DEC-9A-C7AA PDP-9 Advanced Software Checkout Pkg	1.00		N/A	
DEC-9T-QCAA Canrun 7 - Converter Test	Re: DEC-9A C7AA	Re: 9U-SPA2	N/A	1.00
DEC-9T-QMAA Canrun 9 - Macro 9 Test	Re: DEC-9A C7AA	Re: 9U-SPA2	N/A	1.00
DEC-9T-QFBA Fortst - FORTRAN IV Test	Re: DEC-9A C7AA	Re: 9U-SPA2	N/A	1.00

ADVANCED: Miscellaneous

DEC-9A-EUFA Format Generator	1.00		2.50	7.00
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ADVANCED: Listings and Sources

DEC-9U-SPA1-LA I/O Monitor FIV and Library: Listings 1	100.00			
DEC-9U-SPA2-LA I/O Monitor All other: Listings 2	100.00			
DEC-9U-SUA1-LA Keyboard Monitor FIV and Library: Listings 1	100.00			
DEC-9U-SUA2-LA Keyboard Monitor All other: Listings 2	100.00			

	<u>Document</u>	<u>List</u>	<u>Binary</u>	<u>ASCII</u>
DEC-9U-SUBA-UA Keyboard Monitor - ASCII FIV Compiler, Tape 1 of 2	30.00 (DECtape)			
DEC-9U-SUBB-UA KM - ASCII FIV Compiler, Tape 2 of 2	30.00 (DECtape)			
DEC-9U-SUBC-UA KM - ASCII .LOAD, .SYSLD, UPDATE, .SGEN1, DUMP, .SGEN2, .KM9BT, SYSDIR, MONITO, SYSTEM, KM9	30.00 (DECtape)			
DEC-9U-SUBD-UA KM - ASCII I/O HANDLERS and CONV	30.00 (DECtape)			
DEC-9U-SUBE-UA KM - ASCII MACRO9, DDT, EDIT9, PIP9	30.00 (DECtape)			
DEC-9U-SUBF-UA KM-ASCII FIV Library: INTRIN, ABS, IABS, DABS, AINT, INT, IDINT, AMOD, MOD, DMOD, FLOAT, IFIX, SIGN, DSIGN, ISIGN, DIM, IDIM, SNGL, DBLE, IMNMX, RMNMX, DMNMX, .BB, .BC	30.00 (DECtape)			
DEC-9U-SUBG-UA KM-ASCII FIV Library: .BD, .BE, .BF, .BG .BH, EXTERN, SQ RT, SIN, COS, ATAN, ATAN2, EXP, ALOG, ALOG10, TANH, .EB, .ED, .EE, .EF, .EC, DSQ RT, DSIN, DCOS, DATAN	30.00 (DECtape)			
DEC-9U-SUBH-UA KM-ASCII FIV Library: DATAN2, DEXP, DLOG, DLOG10, .DD, .DB, .DE, .DF, .DC, .DA, REAL (EAE), INTEGE (EAE), DOUBLE (EAE)	30.00 (DECtape)			
DEC-9U-SUBI-UA KM-ASCII FIV Library: BINIO, AUXIO, .SS, GOTO, STOP, PAUSE, SPMSG, FIOPS, OSTER, REAL (NON-EAE), INTEGE (NON-EAE), DOUBLE (NON-EAE), BCDIO	30.00 (DECtape)			

BASIC SOFTWARE SYSTEM - Items marked with † are available only in the Basic Mod Kit.

DEC-9B-ABAA Symbolic Assembler	2.00	†	2.50	†
DEC-9B-ABEA Supplement to Symbolic Assembler Ext	Re: 9B-ABAA	†	2.50	†
DEC-9B-AFT0 FORTRAN II	2.00			
DEC-9B-AFT1 FORTRAN Compiler	Re: 9B-AFT0	†	2.50	†

	<u>Document</u>	<u>List</u>	<u>Binary</u>	<u>ASCII</u>
DEC-9B-AFT2 FORTRAN Assembler	Re: 9B-AFT0	†	2.50	†
DEC-9B-AFT3 FORTRAN OTS	Re: 9B-AFT0	†	2.50	†
DEC-9B-AFT5 FORTRAN I/O Library	Re: 9B-AFT0	†	2.50	†
DEC-9B-AFT6 FORTRAN Math. Subroutines	Re: 9B-AFT0	†	2.50	†
DEC-9B-AFT7 FORTRAN Math. Subroutines	Re: 9B-AFT0	†	2.50	†
DEC-9B-CDDA DDT	2.00	†	2.50	†
DEC-9B-CDDA Change Notice to DDT	Re: 9B-CDDA	†		
DEC-9B-CDEA DDT Extended	Re: 9B-CDDA	†	2.50	†
DEC-9B-CT1A Extended Trace	Re: 9B-GSAA	†	PU- 1.00 PH- 1.00	† †
DEC-9B-ESAA Symbolic Editor Manual	2.00			
DEC-9B-ESAB Supplement to Symbolic Editor		†	2.50	†
DEC-9B-GSAA Basic Software Manual	6.00			
DEC-9B-LRIA Read-in Mode Loader	Re: 9B-GSAA	N/A	1.00	N/A
DEC-9B-LFFA Funny Format Loader	Re: 9B-GSAA	†	N/A	3.50
DEC-9B-POT1 Teletype Octal Dump (low)	Re: 9B-GSAA	†	1.00	†
DEC-9B-POT2 Teletype Octal Dump (high)	Re: 9B-GSAA	†	1.00	†
DEC-9B-PT1a TIC TOC	Re: 9B-GSAA	†	N/A	(4) 14.00
DEC-9B-PTMA Master Tape Duplicator	Re: 9B-GSAA	†	1.00	†
DEC-9B-PYP1 Rim Puncher (low)	Re: 9B-GSAA	†	1.00	†
DEC-9B-PYP2 Rim Puncher (high)	Re: 9B-GSAA	†	2.50	†
DEC-9B-QDPA Double Precision Integer Test	Re: 9B-GSAA	†	N/A	3.50
DEC-9B-QF1A FORTRAN Operating Test	Re: 9B-GSAA	†	N/A	(3) 10.50
DEC-9B-QFPA Floating Point Test	Re: 9B-GSAA	†	N/A	3.50
DEC-9B-SDPA Double Precision Integer Pkg.	Re: 9B-GSAA	†	N/A	3.50
DEC-9B-SFPA Floating Point Package	Re: 9B-GSAA	†	N/A	10.50

	<u>Document</u>	<u>List</u>	<u>Binary</u>	<u>ASCII</u>
DEC-9B-SUFA Fast 9	2.00		Paper tape 5.00 DECtape 30.00	5.00
DEC-09-PHA0 HRI Mode Puncher	1.00		(2) 1.00	3.50
DEC-9A-USA0 Multianalyzer Manual	2.00			
DEC-9A-USA1 Multianalyzer	3.00		3.00	(5) 15.00
DEC-9A-USA2 Multianalyzer	3.00		3.00	(5) 15.00
DEC-9A-USA3 Multianalyzer	3.00		3.00	(5) 15.00
DEC-9A-USA4 Multianalyzer	3.00		3.00	(5) 15.00
DEC-9A-USA5 Multianalyzer	3.00		3.00	(5) 15.00
DEC-9A-USA6 Multianalyzer	3.00		3.00	(5) 15.00
DEC-9A-USA7 Multianalyzer	3.00		3.00	(9) 25.00

All MAINDEC writeups, which include listings, can be purchased for \$1.00 each. Those basic MAINDECS marked with an * may be purchased as a package, at \$20.00 for the listings and \$30.00 for the binary tapes.

	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
*MAINDEC-9A-DO1A Instruction Test - Part 1	1.00		5.00	30.00
*MAINDEC-9A-DO2A Instruction Test - Part 2	1.00		2.50	28.00
*MAINDEC-9A-DOBA ISZ Test	1.00		1.00	3.50
*MAINDEC-9A-DOCA Memory Address Test	1.00		1.00	3.50
*MAINDEC-9A-DODB JMP - Self Test	1.00		1.00	3.50
*MAINDEC-9A-DOEA JMP-Y Interrupt Test	1.00		1.00	3.50
*MAINDEC-9A-DOFA JMS-Y Interrupt Test	1.00		1.00	3.50
MAINDEC-9A-DOGA EAE - Part 1	1.00		2.50	14.00
MAINDEC-9A-DOHB EAE Part II	1.00		2.50	14.00
MAINDEC-9A-DOIA API Test	1.00		2.50	10.50
MAINDEC-9A-DOJA KPO9A Power Failure Detection Test	1.00		1.00	3.50
*MAINDEC-9A-D1AA Basic Memory Checkerboard	1.00		1.00	3.50
*MAINDEC-9A-D1BA Extended Memory Checkerboard	1.00		2.50	7.00

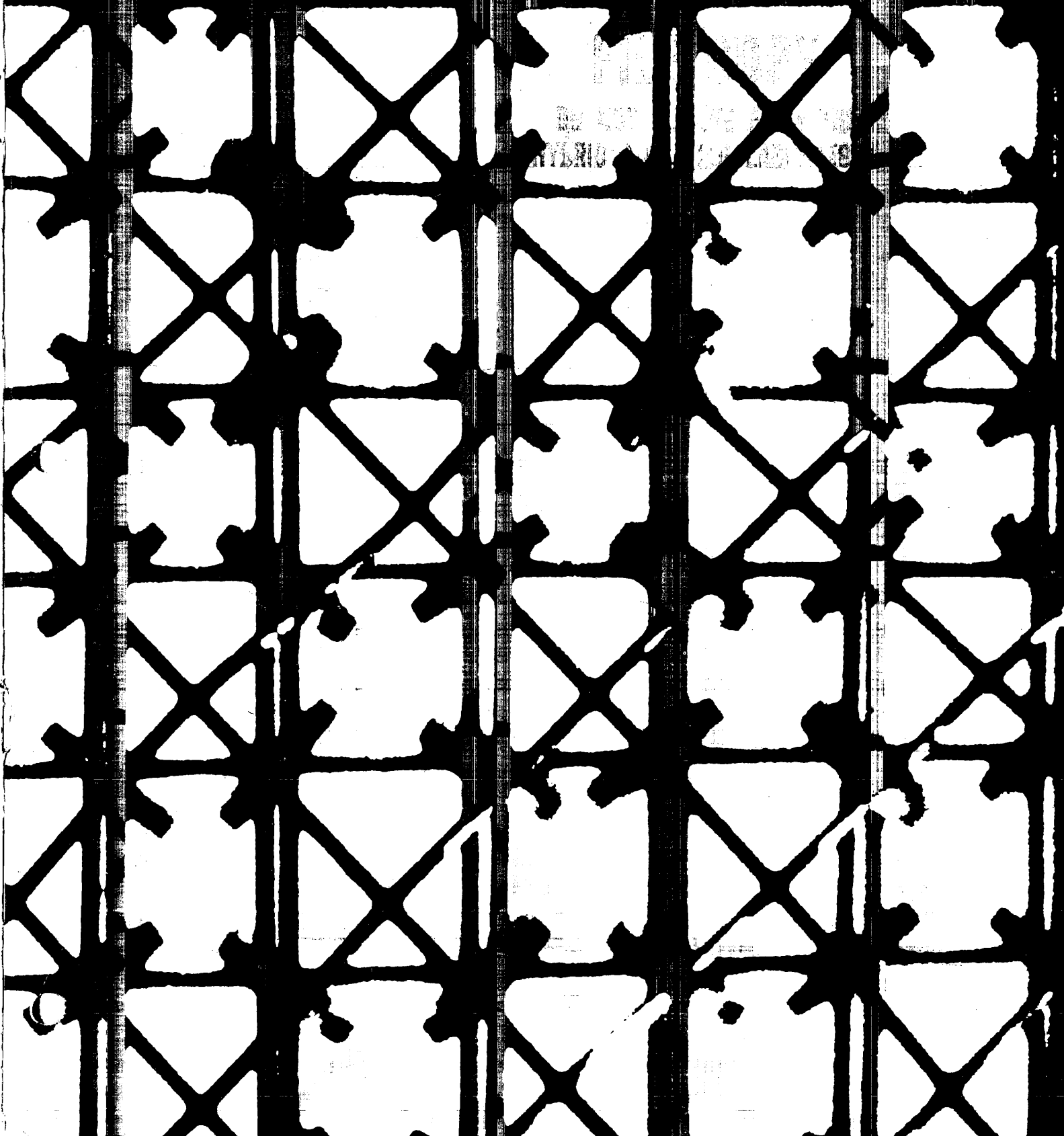
	<u>Document</u>	<u>List</u>	<u>B. or R.</u>	<u>ASCII</u>
MAINDEC-9A-D1CC Extended Memory Control	1.00		1.00	N/A
MAINDEC-9A-D1DB MP09A Parity Option Test	1.00		1.00	N/A
MAINDEC-9A-D1EA KX09A Memory Protect Test	1.00		1.00	N/A
*MAINDEC-9A-D1FA Extended Memory Address Test	1.00		2.50	N/A
*MAINDEC-9A-D2BA TTY Test	1.00		2.50	7.00
*MAINDEC-9A-D2CC PDP-9 High Speed Reader Test	1.00		2.50	3.50
*MAINDEC-9A-D2DB PDP-9 Punch Test	1.00		2.50	7.00
MAINDEC-9A-D2EA CRO2B Burrough Card Reader Test	1.00		1.00	3.50
MAINDEC-9A-D2FB CRO1E NCR Card Reader Test	1.00		1.00	3.50
MAINDEC-9A-D2LA Line Printer Test	1.00		2.50	15.00
MAINDEC-9A-D3BB TCO2 Basic Exerciser	1.00		2.50	21.00
MAINDEC-9A-D3RB TCO2 Random Exerciser	1.00		2.50	10.50
MAINDEC-9A-D4AA TC59 Control Test	1.00		2.50	N/A
MAINDEC-9A-D4BA TC59 Utility Test	1.00		2.50	N/A
MAINDEC-9A-D4CA TC59 Drive Function Timer	1.00		2.50	10.50
MAINDEC-9A-D4DA TC59 7 Track Data Reliability Test	1.00		2.50	17.50
MAINDEC-9A-D4EA TC59 9 Track Data Reliability Test	1.00		2.50	17.50
MAINDEC-9A-D4FA TC59 Random Exerciser-Executive Routine	1.00		2.50	7.00
MAINDEC-9A-D4GA TC59 Random Exerciser	1.00		2.50	10.50
MAINDEC-9A-D5BA RMO9 Drum Test & Maint. Compiler	1.00		2.50	7.00
MAINDEC-9A-D5CA RMO9-Data Pack. Drum Test and Maint. Comp	1.00		2.50	7.00
MAINDEC-9A-D5DA RBO9T1-WC Register and MA Reg. Exercise	1.00		1.00	3.50
MAINDEC-9A-D5EA RBO9T2-SA, TA and SAC Register Test	1.00		1.00	3.50
	<u>Document</u>	<u>List</u>	<u>Binary</u>	<u>ASCII</u>
MAINDEC-9A-D5FA RBO9T3-Disk and Control Exerciser	1.00		2.50	3.50
MAINDEC-9A-D5GA RBO9T4-Status and Control Diagnostic	1.00		2.50	10.50

	<u>Document</u>	<u>List</u>	<u>Binary</u>	<u>ASCII</u>
MAINDEC-9A-D5HA RBO9T5-Part 1 and Part 2	1.00		1.00	7.00
MAINDEC-9A-D5IA RBO9T6-Data Parity Check	1.00		1.00	5.25
MAINDEC-9A-D5JA RBO9T7- Disk Surface Evaluation Prog.	1.00		2.50	3.50
MAINDEC-9A-D6GA A/D Calibration Check	1.00		1.00	3.50
MAINDEC-9A-D6AB Display Diagnostic (30D, 34H, 370)	1.00		1.00	7.00
MAINDEC-9A-D6CA Cal Comp Plotter Test	1.00		2.50	3.50
MAINDEC-9A-D6HA AF04B Diagnostic and Demonstration	1.00		1.00	3.50
MAINDEC-9A-D6JA 339 PJMP Test	1.00		1.00	3.50
MAINDEC-9A-D6KA 339 POP Test	1.00		1.00	3.50
MAINDEC-9A-D6LA 339 Push-Button Test	1.00		1.00	3.50
MAINDEC-9A-D6MA 339 Instruction Test	1.00		2.50	15.00
MAINDEC-9A-D6NA 339 Visual Display Test	1.00		2.50	7.00
MAINDEC-9A-D6OA Little Pictures for a 339	1.00		1.00	3.50
MAINDEC-9A-D6PA VF38 Search Logic Test	1.00		1.00	3.50
MAINDEC-9A-D6QA Character Generator Test	1.00		1.00	3.50
MAINDEC-9A-D6RA 342 Character Generator Typein Prog.	1.00		1.00	3.50
*MAINDEC-9A-D7AC PDP-9 Basic Exerciser	1.00		2.50	21.00
MAINDEC-9A-D7IO DB98 Test	1.00		8 side 1.00 9 side 1.00	7.00 3.50
MAINDEC-9A-D8AA DB97A Diagnostic	1.00		2.50	5.25
MAINDEC-9A-D8BA Relav Buffer Test	1.00		1.00	3.50
MAINDEC-9A-D8CA Lt09 Diagnostic	1.00		2.00	(3) 8.75
MAINDEC-9A-D8IA DB09A Test	1.00		1.00	3.50



DECUSCOPE

DIGITAL EQUIPMENT CORPORATION USER SOCIETY



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NOTE

Cartoon (Linus) on page 1 of DECUSCOPE, Vol. 7, No. 2, was plotted using software developed by John Fitzgerald, Stanford University Medical School.

PRESIDENT'S MESSAGE TO DECUS

The Spring DECUS meeting was considered a success by all. It produced the largest attendance to date with about 285 conferees. Everyone seemed pleased with the agenda of one day for applications oriented papers and one day for workshops on the various product lines. We plan to continue along with this same format.

The Fall DECUS meeting will be in San Francisco. Since the FJCC will be Monday through Wednesday, we plan to hold forth on Thursday and Friday, December 12-13. The meeting will be held at the Jack Tar Hotel. The Spring 1969 DECUS meeting is now planned for Boston in conjunction with the SJCC. The dates of the SJCC are Tuesday-Thursday, May 13-15. The DECUS Executive Board has decided that meeting participation will be such at that time that we will need a three-day meeting. An informal poll of the membership was taken at this last meeting, and the following alternatives were most popular: Friday, Saturday, and Monday before the SJCC; and Thursday (overlap), Friday, and Saturday during and after the SJCC. If anyone has preferences, would they please send a note to Angela to state the preference.

I am happy to announce the following persons have been appointed to fill out the remainder of the Executive Board terms: Dr. Dan Forsyth, University of Vermont, as Recording Secretary and Mr. George Cooper of Logic, Inc., as Publications Chairman. Dave Friesen, formerly of MIT and now of DEC, has agreed to serve as a member of the Programming Committee to coordinate DECUS efforts in the PDP-6/10 area. Phil Bevington is covering the PDP-9 area, while Programming Chairman Mike Wolfberg is taking care of PDP-8 problems in the Society.

DECUS has been very active in the Joint User Group activities. Particularly, we have agreed to submit program documentation to the JUG Program Library Interchange Project. The vehicle for the interchange will be the JUG Program Library Catalog to be published about November 1. This Catalog will contain initially program abstracts of some 2000 programs representing fourteen user groups, and will eventually list abstracts of most of the programs produced in the country. A DECUS member will be able to get documentation on any of the programs listed in the Catalog by filling out a program request form and sending it to the DECUS office. In line with our participation in the project, we will have to change our program submittal forms to conform with the JUG standards. There will be no information deleted, and two principle items added: key word descriptors and subject classifications. These new forms will be forthcoming.

At our July Board meeting a proposal was approved to pay air fare expenses from the DECUS treasury to enable the DECUS President to attend the European Seminar once a year and, in turn, bring the European Chairman to the U.S. East Coast meeting. It is hoped that this gesture will help cement relations between the U.S. and European users.

We on the Executive Board are trying to serve the DECUS membership in the best way we know. We are especially interested in getting feedback from the membership. If you have any suggestions or complaints just write them down in a letter to Angela, and it will be taken up during our following monthly Board meeting.

Richard J. McQuillin, DECUS President

DECUS FOURTH EUROPEAN SEMINAR

The fourth European Seminar for DECUS-Europe will be held on September 19, 20 at the Adam Ferguson Building, University of Edinburgh, Scotland.

Chairman of the two-day session is the DECUS-Europe Chairman (Hoogovens-Holland). Hoogovens graciously hosted last year's seminar. Among the speakers at the meeting will be the DECUS President Richard McQuillin (Inforonics, Inc.).

Several papers will be presented according to Papers Secretary John Hall (AERE Harwell), along with a Biomedical Workshop.

Accommodation Secretary Dr. J. V. Oldfield (University of Edinburgh) has arranged accommodations for attendees at St. Leonard's Hall.

Special thanks to Gillian Spittle and Liz Tisley of the DEC Reading Office for all their help in the organization and preparation of the meeting.

Papers scheduled for presentation follow.

PDP-8 Computer System at SINTEF, Technical University of Norway

Mr. Bengt Jorgensen, Technical University of Norway

PROGOL - A Real-Time Programming System for the PDP-8

Mr. Olaf Hosoién, SINTEF, Norway

POPS - An Algol Subset for Interactive Computation on PDP-8

Mr. Trygve Matre, Technical University of Norway

Some Comments on Online Spectrum Stabilisation

Mr. Neil Lawley, Liverpool University, England

Coupling of Two PDP-8s and a DECTape with a Multichannel Analyser to Perform On Line the Real Time Tasks of a Nuclear Experiment Together with Parallel Data Analysis

M. Jacques Pain, Commissariat a l'Energie Atomique, France

The PDP-8 System for Positioning and Control of the Radio-telescope at Narçay

M. J.-C. Ribes and Mlle. Odile Franquelin, Radioastronomie-Narçay, France

PDP-8 as an Input Spooler to a Multi-Processing KDF-9

J. Wheater, Rolls Royce Bristol Engine Division, England

Three Small On-Line Computers for Blast Furnace Control

Mr. H. Broekhuis, Hoogovens, Holland

A Small Computer as an Aid in Steelmaking

M. v. Overveld, Hoogovens, Holland

On-Line Statistical Analysis of Surface Roughness by Means of a PDP-8

Mr. Jan Erik Torjusén, Technical University of Norway

An Extension to the "Patch Making" Facilities of DDT

Mr. I. Alcock, Scotland

Pseudorandom Digital Transformation in Megachannel Analysis

Mr. Vladimir Bonacic, Institute "Rudjer Boskovic," Yugoslavia

Applications of the LINC On-Line to Recording and Measurement of Neurological Events

Dr. C. Malpus, University of Leeds, England

Commercial Applications of Small Scientific Computers

Mr. D. Roberts, Strand Hotels Ltd., England

Signal Identification System

Mr. L. M. Meyers, Technological University, Holland

BATMAN, an Editing and Assembly System for a PDP-8 Computer with a Drum Backing Store

Miss M. R. Avery, A.E.R.E. Harwell, England

The Liverpool Online Data Acquisition and Analysis System

Mr. P. F. Alderson, University of Liverpool, England

HELP - An Aid to Hybrid Computing

A.W.J. Griffin, University College, England

Computer Control in an Electronic Music Studio

Dr. Peter Zinovieff, England

"Amusement-8"

Dr. John Elder, University of Cambridge, England

Extensions to an 8-FORTRAN System and its Use in Conjunction with LINCtape

Prof. G. R. Hervey, University of Leeds, England

DECUS Biomedical Meeting Papers

The On-Line Control of Psychological Testing: The Perceptual Maze Test

Miss E. Kydd, A. Elithorn, and D. Jones, Royal Free Hospital, England

Use of LINC-8 for Processing Electrical Activity of the Brain in Man

Dr. R. Cooper, W. J. Warren, and W. G. Walter, Burden Neurological Institute, England

ECG Analysis by Computer and Body Surface Isopotential Mapping by Computer

M. P. Macfarlane, Royal Infirmary, Scotland

Isopotential Mapping of the Human Thorax

B. D. Young, Royal Infirmary, Scotland

THE FAST FOURIER TRANSFORM AND ITS IMPLEMENTATION

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Digital Equipment Corporation
Maynard, Massachusetts

I. General

The Discrete Fourier Transform (DFT) of a set of N equally-spaced time samples X_0, X_1, \dots, X_{N-1} is defined as:

$$S_i = \sum_{k=0}^{N-1} X_k W^{ik}$$

where $W = e^{-\frac{2\pi i}{N}}$ and $i = \sqrt{-1}$. The collection S_0, S_1, \dots, S_{N-1} is called the frequency spectrum of the data set $\{X_i\}$. It would seem that computation of the complete spectrum $\{S_i\}$ would require N^2 complex multiplications. But if N is an integer power of 2, then an algorithm developed by Cooley and Tukey¹ called the Fast Fourier Transform (FFT) enables computation of the spectrum with only $N \log_2 N$ complex multiples. This important development can reduce computation time by as much as 99 percent. The purpose of this paper is to present and verify that algorithm as well as to explain its implementation.

II. The FFT Algorithm

No reasons will be given for the validity of the algorithm; however, a set of rules will be presented in this section. It is hoped that the reader will blindly accept them until they are verified in the next section.

Suppose there are N time samples to be transformed and that N is an integer power of 2; that is, $N = 2^\gamma$. Draw a vertical array of N nodes and associate sample X_0 with the first node (which will be labeled 0), X_1 with the second node (which will be labeled 1), and so on (see Figure 1). Call this vertical array X^0 , so that the sample X_k is associated with the k^{th} node of X^0 . Remember that k runs from 0 to $N-1$; k will be expressed as a binary number. Now draw in γ other such vertical arrays of N nodes to the right of X^0 . Label the vertical array immediately to the right of X^0 by X^1 and the one to the right of X^1 as X^2 and so on to X^γ .

Just as in Figure 1, each node or circle in the drawing has a number within it.

*After September, 1968, 813 Yale Station, New Haven, Connecticut.

Each node also has a number associated with it but not inside it. The number X_k^ℓ is the number associated with the k^{th} node in the ℓ^{th} array. Rules for computing these numbers will be given shortly.

One notices that every node has a solid and a dashed line drawn to it from two nodes in the previous array. These lines will now be used in computing the numbers X_k^ℓ associated with the various nodes. Call the number in the k^{th} node of the ℓ^{th} array C . Suppose the solid line is drawn to that node from node A and that the dashed line comes from node B in the previous array. X_k^ℓ is formed as follows: Take the number associated with A and multiply by W^C . Add this to the number associated with B; that is, X_k^ℓ . The solid line denotes a multiplication process, whereas the dashed line indicates addition. Thus, in Figure 1 the number associated with the second node ($k=2$) in the first array ($\ell=1$), (k is written in binary) is given by:

$$X_{(10)}^1 = X_{(10)}^0 W^2 + X_{(00)}^0 \quad (II-1)$$

because this node contains a 2 inside, indicating that the solid line comes from node 10 in array 0 and that the dashed line emanates from the node 00.

The number within the k^{th} node of the ℓ^{th} array is formed by the following process: Write k as a binary number of γ bits. Scale that number ($\gamma - \ell$) places to the right, filling the newly vacated bit positions with zeroes. Then reverse the order of the bits (or invert the bits). For example, let $\gamma=4$, $k=6$, and $\ell=3$. In binary form $k=0110$. Scaling this $\gamma - \ell = 1$ places to the right gives 0011. Reversing the order of the bits makes the number in the 6^{th} node of the 3^{rd} array 1100 = 12.

Let the binary representation of k be:

$$k = k_{\gamma-1} k_{\gamma-2} k_{\gamma-3} \dots k_2 k_1 k_0 \quad (II-2)$$

where each k_i is a bit of value 0 or 1. Then the procedure for locating the solid and dashed arrows of the k^{th} node in the ℓ^{th} array is as follows: The solid line to the k^{th} node in the ℓ^{th} array comes from the node in the $\ell-1^{\text{st}}$ array whose address is the same as k 's except bit $k_{\gamma-\ell}$ is set to 1. The dashed line stems from the node in the $\ell-1^{\text{st}}$ array whose address is the same but bit $k_{\gamma-\ell}$ must be 0. For example, take the second node ($k=10$) in the 2^{nd} ($\ell=2$) array. Here $\gamma - \ell = 2 - 2 = 0$. Now $k = k_1 k_0 = 10$. Setting $k_0 = 1$ gives 11 so

the solid line comes from node 11 in array 1. Putting $k_0=0$ results in 10. Thus, the dashed line comes from node 10, as shown in Figure 1.

The Fourier Transforms are given by the numbers associated with the rightmost array X^γ , in bit inverted order. For example:

$$S_{(01)} = X_{(10)}^2 \quad \text{and} \quad S_{(10)} = X_{(01)}^2 \quad (II-3)$$

By using the above rules, a tree-graph for any $N=2^\gamma$ inputs can be drawn. The numbers associated with the nodes in the first array are calculated from the inputs by using the arrows. The numbers of the second array are calculated from those of the first, and so on, until the numbers associated with the last array are known. These are then unscrambled by bit inversion and are the Fourier Transforms. The tree-graph for $N=8$ is shown in Figure 2.

Notice in Figures 1 and 2 that there is always one pair of nodes in each array which has solid and dashed arrows coming from the same nodes in the previous array. Also observe that the difference of the numbers held within each pair of nodes is always $N/2$. For example, in Figure 1 look at nodes 00 and 01 of array 2. Both have dashed arrows coming from $X_{(00)}^1$ and solid arrows from $X_{(01)}^1$. And the difference between the numbers in the nodes is $2-0=2=4/2=N/2$.

Because

$$W^{i+\frac{N}{2}} = W^i W^{\frac{N}{2}} = W^i [\cos\pi - j\sin\pi] = -W^i$$

only half the number of multiplications are actually needed.

To illustrate this, consider the node pair $X_{(00)}^2$ and $X_{(01)}^2$.

From the graph in Figure 1,

$$X_{(00)}^2 = X_{(00)}^1 + X_{(01)}^1 W^0 \quad (II-4)$$

$$X_{(01)}^2 = X_{(00)}^1 + X_{(01)}^1 W^2 = X_{(00)}^1 - X_{(01)}^1 W^0$$

Because

$$W^2 = W^{0+2} = W^{0+\frac{N}{2}} = -W^0$$

III. Proof of Validity

Matrix algebra provides a convenient way to verify the FFT algorithm. If X^p represents the p^{th} vertical array of nodes (p runs from 0 to γ), then X^p can be represented as a column vector by:

$$X^p = \begin{pmatrix} X_0^p \\ X_1^p \\ \vdots \\ X_{N-1}^p \end{pmatrix} \quad (III-1)$$

X^0 is the column vector consisting of the N data samples.

To express X^p in terms of X^{p-1} , take

$$X^p = C^p X^{p-1} \quad (III-2)$$

and solve for C^p for each p , giving a recursion formula which will enable computation of X^γ (the transforms) from X^0 (the samples).

Define $R_\ell(i)$ to be i shifted ℓ places right with 0's filling in the vacated positions and \tilde{i} to be bit inverted i . Denote $[R_\ell(i)]$ by $\tilde{R}_\ell(i)$.

Consider X_i^p , the number associated with the i^{th} node in the p^{th} array. Writing i in terms of its bit structure:

$$i = i_{\gamma-1} i_{\gamma-2} \cdots i_1 i_0 \quad (III-3)$$

The algorithm gives

$$X_i^p = X_{i_{\gamma-1} i_{\gamma-2} \cdots i_{\gamma-p-1} 0 i_{\gamma-p-1} i_0}^{p-1} + W_{\tilde{R}_{\gamma-p}(i)} X_{i_{\gamma-1} \cdots i_{\gamma-p+1} i_{\gamma-p} \cdots i_0}^{p-1} \quad (III-4)$$

where the 1 and 0 replace the bit $i_{\gamma-p}$. Define the two operators Z_n and I_n so that

$$Z_n(i) = i_{\gamma-1} i_{\gamma-2} \cdots i_{\gamma-n+1} 0 i_{\gamma-n-1} \cdots i_1 i_0 \quad (III-5)$$

and

$$I_n(i) = i_{\gamma-1} i_{\gamma-2} \cdots i_{\gamma-n+1} 1 i_{\gamma-n-1} \cdots i_1 i_0 \quad (III-6)$$

In this notation

$$X_i^p = X_{Z_p(i)}^{p-1} + X_{I_p(i)}^{p-1} W_{\tilde{R}_{\gamma-p}(i)} \quad (III-7)$$

From (III-2) and the definition of matrix multiplication

$$X_i^p = \sum_{k=0}^{N-1} C_{ik}^p X_k^{p-1} \quad (III-8)$$

where C_{ik}^p are the components of matrix C^p . From (III-7) and (III-8) these components are given by:

$$C_{ik}^p = W_{\tilde{R}_{\gamma-p}(i)} \quad \text{if } k = I_p(i) \quad (III-9)$$

$$C_{ik}^p = 1 \quad \text{if } k = Z_p(i)$$

$$C_{ik}^p = 0 \quad \text{in all other cases}$$

for each $p=1, 2, \dots, \gamma$. By the recursion formula (III-2)

$$X^\gamma = C^\gamma X^{\gamma-1} = C^\gamma (C^{\gamma-1} X^{\gamma-2}) = C^\gamma C^{\gamma-1} C^{\gamma-2} \dots C^2 C^1 X^0$$

$$= \left[\prod_{k=0}^{\gamma-1} C^{\gamma-k} \right] X^0 \quad (III-10)$$

By the definition of matrix multiplication extended to γ matrices, the pq^{th} element of $\prod_k C^{\gamma-k}$ is

$$\left[\prod_{k=0}^{\gamma-1} C^{\gamma-k} \right]_{pq} = \sum_{l_1, l_2, \dots, l_{\gamma-1}}^{N-1} \left\{ C^\gamma_{p l_{\gamma-1}} C^{\gamma-1}_{l_{\gamma-1} l_{\gamma-2}} \dots C^2_{l_2 l_1} C^1_{l_1 q} \right\} \quad (III-11)$$

where $l_1, l_2, \dots, l_{\gamma-1}$ are dummy indices running from 0 to $N-1$. Make the following identifications:

$$l_\gamma \equiv p, \quad l_0 \equiv q \quad (III-12)$$

In terms of (III-12), (III-11) becomes

$$\left[\prod_{k=0}^{\gamma-1} C^{\gamma-k} \right]_{l_\gamma l_0} = \sum_{l_1, \dots, l_{\gamma-1}}^{N-1} \prod_{i=0}^{\gamma-1} C^{\gamma-i}_{l_{\gamma-i} l_{\gamma-i-1}} \quad (III-13)$$

From (III-10) and the definition of matrix multiplication

$$X_{l_\gamma l_0}^\gamma = \sum_{l_0=0}^{N-1} \left\{ \sum_{l_1, \dots, l_{\gamma-1}}^{N-1} \prod_{i=0}^{\gamma-1} C^{\gamma-i}_{l_{\gamma-i} l_{\gamma-i-1}} \right\} X_{l_0}^0 \quad (III-14)$$

(III-14) is of the form of a discrete Fourier Transformation so it is reasonable to proceed by calculating the coefficients

$$\sum_{l_1, \dots, l_{\gamma-1}}^{N-1} \prod_i C^{\gamma-i}_{l_{\gamma-i} l_{\gamma-i-1}}$$

Now, if a term $\prod_i C^{\gamma-i}_{l_{\gamma-i} l_{\gamma-i-1}}$ is not to vanish (and all vanishing terms contribute nothing to the summation) then each term $C^{\gamma-i}_{l_{\gamma-i} l_{\gamma-i-1}}$ in the multiplication must not vanish.

According to (III-9) this means that either

$$l_{\gamma-i-1} = Z_{\gamma-i}(l_{\gamma-i}) \quad (III-15)$$

or

$$l_{\gamma-i-1} = I_{\gamma-i}(l_{\gamma-i})$$

Specifically for $i=0$ and $i=\gamma-1$, (III-15) gives

$$l_{\gamma-1} = Z_\gamma(l_\gamma) = Z_\gamma(p) \quad \text{or} \quad l_{\gamma-1} = I_\gamma(p) \quad (III-16)$$

and

$$l_0 = q = Z_1(l_1) \quad \text{or} \quad q = I_1(l_1)$$

Denote by $Z_1 Z_2 Z_3 \dots I_4(i)$ the composition of operators $Z_1(Z_2(Z_3(I_4(i))))$ and let this definition include any number and permutation of the operators Z_i and I_i . From (III-15) and (III-16) the set of N^2 recursion formulas becomes:

$$q = I_1 I_2 \dots I_\gamma(p) \quad \text{or} \quad I_1 I_2 \dots Z_\gamma(p) \quad \text{or} \quad I_1 I_2 \dots Z_{\gamma-1} I_\gamma(p)$$

or $I_1 I_2 \dots I_{\gamma-2} Z_{\gamma-1} Z_\gamma(p)$ etc. through all permutations of operators I and Z . But for each term $\sum \prod_i C^{\gamma-i}_{l_{\gamma-i} l_{\gamma-i-1}}$ p and q ($= l_\gamma$ and l_0) are fixed. That means their bit patterns

$$q = q_{\gamma-1} q_{\gamma-2} \dots q_1 q_0$$

$$p = p_{\gamma-1} p_{\gamma-2} \dots p_1 p_0$$

are also fixed. Note that each element of the operator string Z_i or I_i sets the i^{th} bit of p to 0 or 1, but that each operator in the string has a different value of i , and hence affects a different bit of p . The $i=\gamma$ operator affects bit 0 and the $i=1$ operator affects bit $\gamma-1$ of p . So the operator string affects all bits of p independently. This means that the value of $q = O_1 O_2 \dots O_\gamma(p)$ is independent of p itself: p is a dummy here. (I use O_i to represent the i^{th} operator. O_i could be Z_i or I_i .) Because q is fixed, then, so is the operator string. In fact, defining

$$O_{q_i} = Z_{\gamma-i} \quad \text{if} \quad q_i = 0 \quad (III-17)$$

and

$$O_{q_i} = I_{\gamma-i} \quad \text{if} \quad q_i = 1$$

the operator string $O_1 O_2 \dots O_\gamma$ is just

$$O_{q_{\gamma-1}} O_{q_{\gamma-2}} \dots O_{q_1} O_{q_0}$$

Therefore

$$q = O_{q_{\gamma-1}} O_{q_{\gamma-2}} \dots O_{q_1} O_{q_0}(p) \quad (III-18)$$

and there is only 1 permutation of operators O_i for which the term $\prod_i C^{\gamma-i}_{l_{\gamma-i} l_{\gamma-i-1}}$ does not vanish. From (III-18) the recursion formula (III-15) becomes

$$l_{\gamma-i-1} = O_{q_i}(l_{\gamma-i}) \quad (III-19)$$

In accordance with the definition in (III-17), (III-19) says:

$$C_{l_{\gamma-i} l_{\gamma-i-1}}^{\gamma-i} = 1 \text{ when } q_i = 0 \quad (III-20)$$

$$C_{l_{\gamma-i} l_{\gamma-i-1}}^{\gamma-i} = W_{l_{\gamma-i}}^{\tilde{R}_i(l_{\gamma-i})} \text{ when } q_i = 1$$

Because $W^0 = 1$ (III-20) can be written as

$$C_{l_{\gamma-i} l_{\gamma-i-1}}^{\gamma-i} = W_{l_{\gamma-i}}^{\tilde{R}_i(l_{\gamma-i})} \cdot q_i \quad (III-21)$$

It will be shown that the expression $R_i(l_{\gamma-i})$ is the same as $R_i(l_{\gamma})$. Now

$$l_{\gamma-i} = O_{q_{i-1}} O_{q_{i-2}} \dots O_{q_1} O_{q_0}(l_{\gamma})$$

Denote by $B_{q_i}^j$ the j^{th} bit of $l_{\gamma} (= l_{\gamma}^j)$ after the operator O_{q_i}

has been applied. So

$$l_{\gamma-i} = l_{\gamma-i}^{\gamma-1} l_{\gamma-i}^{\gamma-2} \dots l_{\gamma-i}^i B_{q_{i-1}} B_{q_{i-2}} \dots B_{q_0}$$

$$l_{\gamma}^{\gamma-1} l_{\gamma}^{\gamma-2} \dots l_{\gamma}^i B_{q_{i-1}} B_{q_{i-2}} \dots B_{q_0}$$

since bits $\gamma-1$ to j of l_{γ} are unaffected by $O_{q_{i-1}} \dots O_{q_0}$

Hence

$$R_i(l_{\gamma-i}) = l_{\gamma}^{\gamma-1} l_{\gamma}^{\gamma-2} \dots l_{\gamma}^i = R_i(l_{\gamma})$$

Since the terms $\prod_i C_{l_{\gamma-i} l_{\gamma-i-1}}^{\gamma-i}$ do not vanish only for a particular $l_1, l_2, \dots, l_{\gamma-1}$ the summation is reduced to one term,

$$\sum_{l_1, \dots, l_{\gamma-1}} \prod_i C_{l_{\gamma-i} l_{\gamma-i-1}}^{\gamma-i} = \prod_{i=0}^{\gamma-1} W_{l_{\gamma-i}}^{\tilde{R}_i(l_{\gamma})} \cdot q_i \quad (III-22)$$

Let the operator L_i denote the operation of shifting left by j places, with zeroes filling in the vacated positions. It is apparent that

$$L_i(l_{\gamma}) = \tilde{R}_i(l_{\gamma})$$

Hence

$$\sum_{l_1, \dots, l_{\gamma-1}} \prod_i C_{l_{\gamma-i} l_{\gamma-i-1}}^{\gamma-i} = \prod_{i=0}^{\gamma-1} W_{l_{\gamma-i}}^{L_i(l_{\gamma})} \cdot q_i$$

$$\text{Now } \prod_{i=0}^{\gamma-1} W_{l_{\gamma-i}}^{L_i(l_{\gamma})} \cdot q_i = W_{\left\{ \sum_{i=0}^{\gamma-1} L_i(l_{\gamma}) \cdot q_i \right\}} \quad (III-23)$$

It is easily seen that

$$\sum_{i=0}^{\gamma-1} L_i(l_{\gamma}) \cdot q_i = (l_{\gamma} q) \bmod N = (\tilde{p} q) \bmod N \quad (III-24)$$

(III-24) can be verified by carrying out the product

$(q_{\gamma-1} \dots q_0)(p_0 \dots p_{\gamma-1})$ according to the rules of binary multiplication and then excluding all bits whose positions are higher than $\gamma-1$. Thus putting (III-24) into (III-23) and (III-23) into (III-14)

$$X_p^{\gamma} = \sum_{q=0}^{N-1} W_{(\tilde{p}q) \bmod N} X_q^0 \quad (III-25)$$

Because $W = e^{-2\pi i/N}$, it is obvious that

$$W_{(\tilde{p}q) \bmod N} = W_{\tilde{p}q}$$

Therefore (III-25) becomes

$$X_p^{\gamma} = \sum_{q=0}^{N-1} X_q^0 W_{\tilde{p}q} \quad (III-26)$$

Substituting \tilde{p} for p in (III-26) and using the fact that $\tilde{\tilde{p}} = p$

$$X_{\tilde{p}}^{\gamma} = \sum_{q=0}^{N-1} X_q^0 W_{\tilde{p}q} \quad (III-27)$$

The algorithm says that the p^{th} transform is the number associated with the \tilde{p} node of the last array, or

$$S_p^{\gamma} = X_{\tilde{p}}^{\gamma} \quad (III-28)$$

Combining (III-28) and (III-27) gives

$$S_p^{\gamma} = \sum_{q=0}^{N-1} X_q^0 W_{\tilde{p}q} \quad (III-29)$$

One observes that (III-29), the result of application of the algorithm, is the same as (I-1), the definition of the DFT. Hence the verification is complete.

IV. Implementation of the Algorithm

This section presents and describes in detail a flow chart (the basis for much of this flow chart is a Lincoln Lab Technical Memorandum by Charles Rader⁴) for computation of the FFT of a set of N time samples. An actual program, written in PDP-8 FOCAL*, as well as several sample outputs, are listed.

Use of the flow chart (Figure 3) enables transformation of any

* Trademark of Digital Equipment Corporation

$N=2^v$ points in place. This means that the only major storage requirement consists of the initial data vector. The great reduction in dynamic storage area is accomplished by operating on two nodes at a time—two nodes whose arrows stem from the same pair of nodes in the previous array. Referring to Figures 1 and 2, it is seen that the spacing between two such nodes in array L is always $N/(2^L)$. Also, the difference between the numbers in any two such nodes is always $N/2$. So every node has a "mirror" node which is found by spacing up $N/2^L$ in the array. Taking each node and its mirror image in pairs eliminates the need for additional storage space.

There are several symbols peculiar to the flow chart that need explanation. A function R_v appears in boxes 8 and 15. This denotes the operation of bit reversing the v bit binary number Q . A "squiggly" bracket, $\}$, enclosing several operations means that those operations are to be carried out simultaneously. Finally, the square brackets in the first line of box 8 denote taking the integer part. Now to a detailed explanation of the chart.

Box 1 consists of initialization. N is the number of samples and v the power of 2 to which N corresponds. L gives the number of the array currently being constructed. S is an index which gives the spacing between mirror nodes in each array. It is initialized to $N/2^1 = N/2$. H is the number $-(v-L)$ and is initialized to $-(v-1) = 1-v$.

Boxes 2, 3, and 4 generate the first array from the data vector. The reason for computing the first array apart from the other arrays is that it requires no multiplications (examine Figures 1 and 2 and observe that the nodes in the first array contain only 0 and $N/2$), hence saving computation time. Q , the index of the array, was initialized to one below the middle node so that we move from the middle of the array to the top, adding or subtracting mirrors as specified by the algorithm ($W^{N/2} = -1$).

When this is done, box 5 checks to see if the calculation is complete. If it is, the results are reshuffled into proper order by bit inversion. This is done by boxes 15 through 19. If the computation is not over, we move on to the next array.

Here the crux of the algorithm comes— L becomes $L+1$, signalling the construction of the next array. Also, S becomes $S/2$. Note that on the L^{th} time through S is just $N/2^L$,

exactly the spacing between mirror nodes. H is made to be $H+1$, so its value is $-(v-L)$ when the L^{th} array is being built. Finally, P is $N-1$, pointing to the last item of the current array.

In box 7, C is initialized to 1. C is a counter which indicates how many mirror node pairs have currently been handled.

The basic arithmetic is dealt with in box 8. Lines 1 and 2 scale $P-v-L$ places right and bit invert the result, getting K , the number within the P^{th} node. $W(e^{-2\pi i/N})$ is then raised to the K^{th} power and multiplied by the number associated with the P^{th} node, X_p . Note that W^K can either be calculated on the spot or stored in a look-up table for speed. Because S gives the spacing between mirror nodes, it follows that P 's mirror Q is located at $P-S$. Hence, Q is set to $P-S$. Addition and subtraction operations are then carried out as specified by the algorithm and the mirror nodes in the old array are replaced by their counterparts in the array being produced.

Referring to Figures 1 and 2, one observes that we can proceed linearly up the array in the manner of box 8 up to a certain point. From this point on we would be working with the images of previously encountered nodes. Hence, this region must be skipped over. Since the spacing of mirror nodes is S , it follows that such special points will occur every S nodes. In order to stop linear increase in P (box 9) at such points, C is incremented (box 11) on each cycle through box 8. When $C=S$ (box 10) a special point has been encountered. So it is imperative to space past the "dangerous" area by setting P to $P-S$ (box 13). However, before this is done we must check to see if we are at the top of the array, lest we pioneer into regions which do not exist (box 12). If $P+1=S$ then we are within one "dangerous" region of the top of the current array and are done. If not, we continue as before by spacing up S in the array. The loop, of course, is terminated by box 5.

One must keep in mind that all operations in the flow chart are performed on complex numbers. So both real and complex parts must undergo the indicated operations.

A program using the algorithm in Figure 3 has been written in PDP-8 FOCAL. A listing and some examples are given in Figures 4 and 5. FOCAL itself is an on-line conversational language which, as the length of the program demonstrates, lends itself quite well to the FFT algorithm. The bit inversion

operation is accomplished by a PDP-8 machine language subroutine, shown in Figure 6. FOCAL has a special user function FNEW () which enables the user to define a function simply by writing the machine language code to perform the desired operation. Here FNEW (NU,U) treats U as a binary number of NU bits and then inverts it. When the program text is abbreviated according to the rules of the FOCAL language, the program will transform up to 32 points in 4K of memory. Since the FOCAL program is of value mostly for demonstration and verification purposes, a machine language version is currently being developed by the author. This will transform up to 2048 real points in 4K of memory in under 5 seconds.

References

1. Brigham, E. O., and Morrow, R. E., "The Fast Fourier Transform," IEEE Spectrum, pp. 63-70, December, 1967.
2. Cooley, J. W., and Tukey, J. W., "An Algorithm for the Machine Calculation of Complex Fourier Series," Math of Computers, Vol. 19, pp. 297-301, April, 1965.
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4. Rader, Charles M., Lincoln Lab. (M.I.T.) Technical Memorandum No. 62L-0075, October, 1965.
5. Singleton, Richard C., "On Computing the Fast Fourier Transform," Communications of the ACM, Vol. 10, No. 10, pp. 647-654, October, 1967.
6. "What is the Fast Fourier Transform?" IEEE Transactions on Audio and Electroacoustics, Vol. AU15, No. 2, pp.45-55, June, 1967.

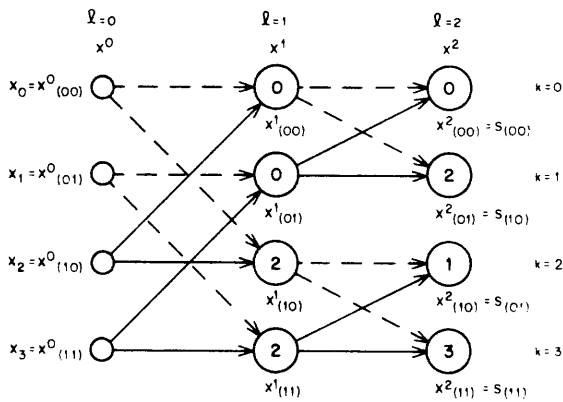
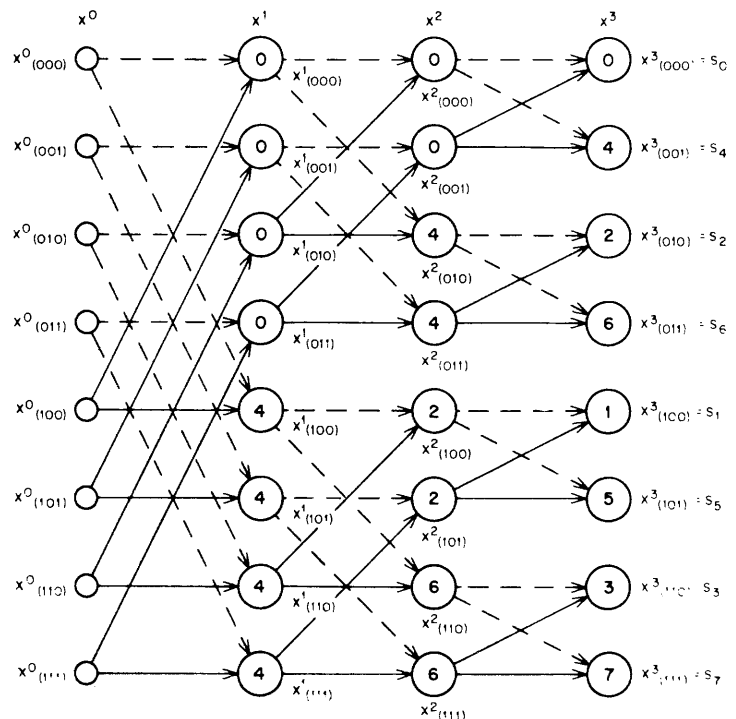


Figure 1. Tree-graph for FFT for N=4

Figure 2. Tree-graph for FFT for N=8



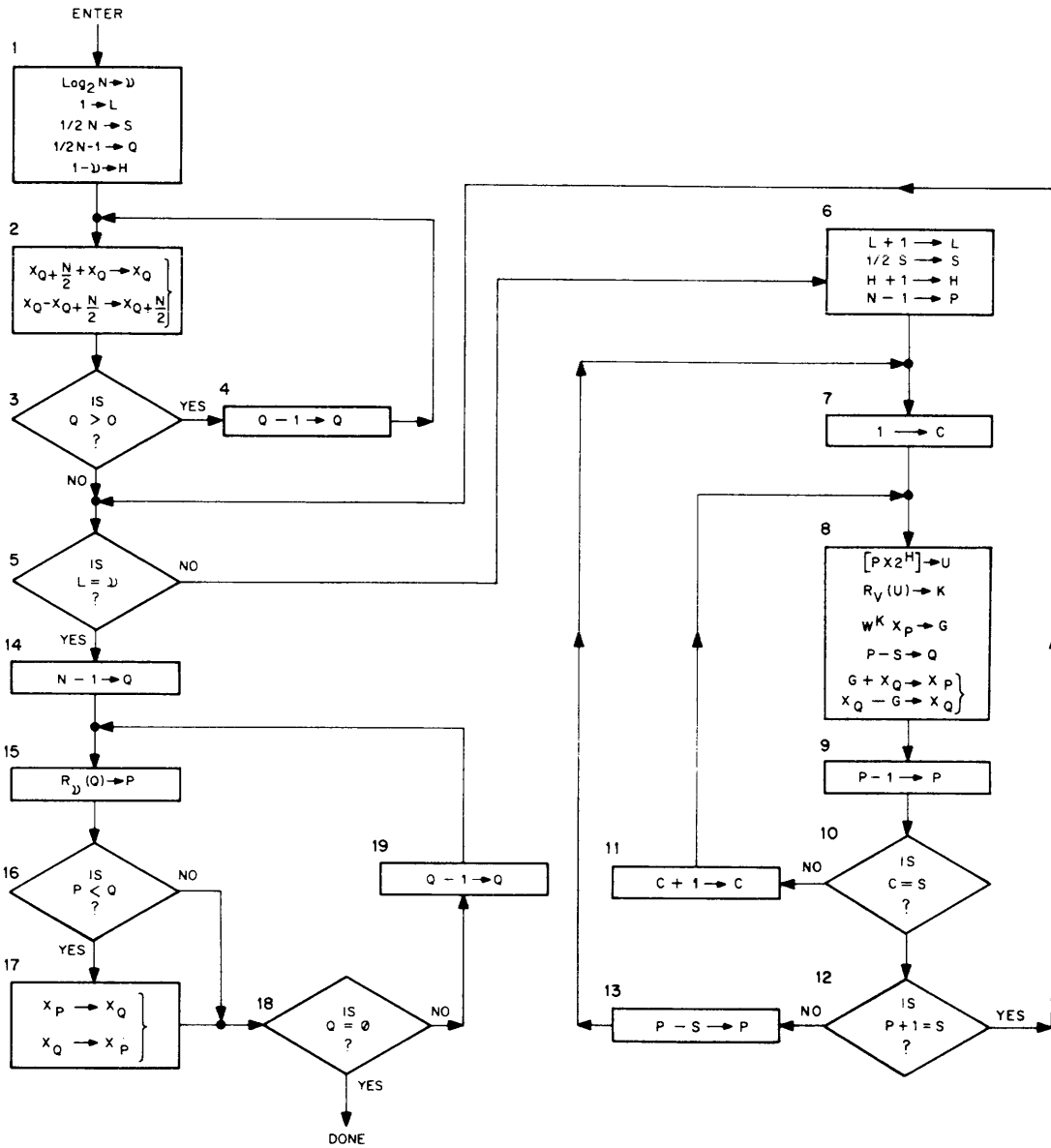


Figure 3. Flowchart for calculation of the Fast Fourier Transform

*C- TRANSFORM OF SINE WAVE OF AMPLITUDE 1.0

```

*
*GO
WHAT POWER OF 2 POINTS ARE TO BE
TRANSFORMED?:3 INPUT THOSE POINTS
:0
: .707
:1
: .707
:0
: -.707
:-1
: -.707

```

FOURIER TRANSFORMS		FREQUENCY (CPS)
REAL PART	IMAGINARY PART	
0.00	0.00	D.C.
0.00	-1.00	1
0.00	0.00	2
0.00	0.00	3
0.00	0.00	4

Figure 4A: Examples of FFT Using FOCAL

*C- TRANSFORM OF COSINE WAVE OF AMPLITUDE 1

```

*GO
WHAT POWER OF 2 POINTS ARE TO BE
TRANSFORMED?:3 INPUT THOSE POINTS.
:1
: .707
:0
: -.707
:-1
: -.707
:0
: .707

```

FOURIER TRANSFORMS	
REAL PART	IMAGINARY PART
0.00	0.00
1.00	0.00
0.00	-0.00
0.00	0.00
0.00	0.00

Figure 4B

*C- TRANSFORM OF INTERFERENCE PATTERN FORMED BY MIXING A SINE
 *C- WAVE OF AMPLITUDE 1.0 AND A COSINE WAVE OF AMPLITUDE 1.5
 *GO

WHAT POWER OF 2 POINTS ARE TO BE TRANSFORMED?:3
 INPUT THOSE POINTS.

FOURIER TRANSFORMS
 REAL PART IMAGINARY PART

:1.5
 :1.768
 :1
 :-.353
 :-1.5
 :-1.768
 :-1
 :.353

0.00	0.00
1.50	-1.00
0.00	0.00
0.00	0.00
0.00	0.00

Figure 4C

```

01.06 ERASE
01.08 ASK "WHAT POWER OF 2 POINTS ARE TO BE TRANSFORMED?",NU,!
01.10 SET N=2*NU; SET TPN=2*3.14159/N; FOR I=0,N-1; SET XI(I)=0
01.18 SET S=N/2; SET L=1; SET Q=S-1; SET H=1-NU
01.20 TYPE "INPUT THOSE POINTS.",!; FOR I=0,N-1; ASK XR(I),!
01.22 SET SR=XR(Q+S)+XR(Q); SET XR(Q+S)=XR(Q)-XR(Q+S);SET XR(Q)=SR
01.24 IF (Q) 1.26,1.26; SET Q=Q-1; GOTO 1.22
01.26 IF (L-NU) 1.28,1.54,1.28
01.28 SET L=L+1; SET S=S/2; SET H=H+1; SET P=N-1; SET Z=1/(2*(-H))
01.32 SET C=1
01.34 SET U=FITR(P*Z); SET K=FNEW(NU,U)
01.36 SET COS=FCOS(TPN*K); SET SN=FSIN(TPN*K)
01.38 SET GR=COS*XR(P)+SN*XI(P); SET GI=COS*XI(P)-SN*XR(P)
01.40 SET Q=P-S; SET SR=GR+XR(Q); SET SI=GI+XI(Q);SET XR(Q)=XR(Q)-GR
01.42 SET XI(Q)=XI(Q)-GI; SET XR(P)=SR; SET XI(P)=SI
01.46 SET P=P-1; IF (C-S) 1.48,1.50,1.48
01.48 SET C=C+1; GOTO 1.34
01.50 IF (P-S+1) 1.52,1.26,1.52
01.52 SET P=P-S; GOTO 1.32
01.54 DO 3; QUIT

03.10 TYPE !,"FOURIER TRANSFORMS",!,"REAL PART   IMAGINARY PART",!!
03.20 FOR I=0,N-1;SET K=FNEW(NU,I);TYPE %3.2,XR(K)/N,"       ",XI(K)/N,!
  
```

Figure 5: Listing of FOCAL Program

/THIS ROUTINE INVERTS THE BIT ORDER OF THE "NU"
 /BIT WORD "U",WHERE NU AND U ARE THE ARGUMENTS OF
 /K=FNEW(NU,U).

```

*27                    /BOTTOM
FLIP-1
*FNTABF+15
FLIP                   /PUT NEW FUNCTION ON TABLE

*4550

FLIP,   JMS I INTEGER    /FIX FLOATING AC (FAC)                    /DEFINITIONS
      TAD FLAC+1        /FIRST ARGUMENT (NU)
      CIA               GETC=4514
      DCA CNTR         /NUMBER OF BITS                            PUSHJ=4507
      SPNOR            /MOVE PAST SPACES                         EVAL=1602
      GETC             /GET PAST COMMA                            INTEGER=52
      PUSHJ            FLAC=44
          EVAL         /EVALUATE SECOND ARGUMENT (U)             FNTABF=374
      JMS I INTEGER    /FIX FAC                                    K=FLAC+2
      DCA K            /BUILD UP RESULT IN K                      U=FLAC+1
FLLOOP, TAD U          /TRANSPOSE U ABOUT ITS CENTER             EFUN3I=106
      CLL RAR         /BY ROTATING U RIGHT AND K LEFT.         SPNOR=4527
      DCA U
      TAD K            /BIT TO BE TRANSPOSED IN LINK.           $
      RAL             /INSERT INTO LOW ORDER BIT OF K.
      DCA K
      ISZ CNTR         /FOR ALL NU BITS.
      JMP FLLOOP
      TAD K            /PUT RESULT IN FLAC+1 AND FLOAT
      DCA FLAC+1
      JMS I FLOAT
      JMP I EFUN3I     /DONE.

FLOAT, 5355
CNTR, 0
  
```

Figure 6: Bit Inversion Subroutine for FOCAL

TECHNICAL SYMPOSIUM

"APPLICATIONS OF SEA-GOING COMPUTERS"
January 13-14, 1969
La Jolla, California

Sponsored by
San Diego Section of the Marine Technology Society
and
MTS Data Engineering Committee, Western Group

A technical symposium on "Applications of Sea-Going Computers" will be co-sponsored by Scripps Institution of Oceanography and the Marine Technology Society at Scripps' campus in January, 1969.

Dr. William A. Nierenberg, Director of Scripps, is General Chairman. In his words, "The conference will concern itself with the use of sea-going computers, which enable scientists to record data more easily and to understand the data at sea rather than to wait for the later, delayed processing of data on shore." The program will review experiences to date with sea-going data processing systems and will examine the potential for computing machinery in military and scientific marine applications.

Executive Co-chairmen are Dr. John Mudie of Scripps and Charles Jackson, Chairman of MTS Data Engineering Committee, Western Group.

The program will consist of four daytime sessions and one evening panel. The subject area is a sequel to the ONR-NSIA "Symposium on Automatic Collection, Processing and Analysis of Oceanographic Data" held at Scripps in December, 1964. Attendance is open to all interested scientists and engineers. Invitations are also being extended to selected foreign scientists.

Authors interested in presenting papers at the conference should submit the title and an abstract of not more than 500 words by September 30, 1968, to:

Dr. John Mudie
Applications of Sea-Going Computers
Scripps Institution of Oceanography
P. O. Box 109
La Jolla, California 92027

Contributors whose topics are selected for presentation at the symposium will be notified by November 15. All manuscripts are due by December 31, 1968. All papers accepted will be published in a special issue of the MTS Journal of Ocean Technology. General information concerning the symposium can be obtained from:

Mr. Charles B. Jackson
MTS Data Engineering Committee
P. O. Box 2158
La Jolla, California 92037

DECUS FALL 1968 SYMPOSIUM

A "Call for Papers" has recently been sent out on the Fall 1968 DECUS Symposium. The symposium, scheduled for December 12 and 13 at the Jack Tar Hotel in San Francisco, will follow directly behind the FJCC (December 9-11). Arrangements have been made to allow DECUS members planning on attending both meetings to register at the Jack Tar for the whole period. Special hotel registration cards for this purpose will be sent to DECUS members shortly.

If you are planning on presenting a paper, participating in a workshop or panel discussion, please return your participation questionnaire attached to the "Call for Papers" as soon as possible.

Session themes - Data Acquisition and Control, Interactive Systems, Education, Biomedicine, PDP-8, PDP-9, PDP-10, and Modules/Hardware workshops have already attracted several interesting papers.

For more details contact the Executive Secretary, DECUS Office, Maynard, Massachusetts 01754, Phone: 617, 897-5111, Ext. 414 or 447

DECUS ELECTIONS

This is not only the year of the "elephant" and the "donkey", but also it's time again for reelection of DECUS officers. This year it's the offices of Equipment Chairman, Publications Chairman, and Programming Chairman.

Nominations to date for these offices are:

Equipment Chairman - Sytko Andrae, Lawrence Radiation Laboratory, Berkeley, California

Publications Chairman - George Cooper, Logic, Inc., Detroit, Michigan

Programming Chairman - Michael S. Wolfberg, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pennsylvania

Additional nominations will be accepted up to October 1. All nominations must be supported by three DECUS members. (DECUS Bylaws, Article IV, Section E, 2d.)

The official list of candidates will appear in the next issue of DECUSCOPE, and ballots will be sent out in early October.

DECUS PROGRAM LIBRARY NOTES NEW PROGRAMS

All new programs accepted since the publication of the June 1968 Library Catalog will be announced in the next issue of DECUSCOPE.

RE: DECUS Programs Nos. 5-13, 8-123, 8-124, and 8-125

Due to reproduction costs involved in completing the numerous requests for card decks for the above listed programs, there

will be a service charge of \$10 for each card deck requested. Anyone requesting one of these programs should send a purchase order or a check made payable to Digital Equipment Corporation to the DECUS Office. All checks should be accompanied by a library material request form.

PROGRAMMING NOTES

FOCAL POINTS

FOCAL POINTS was inaugurated in DECUSCOPE, Vol. 7, No. 2. The purpose of this column is to serve as a forum of comments and/or programs written in DEC's new family-of-8 conversational language, FOCAL. These programs and examples will be kept in printed form only and will usually be distributed in groups. Existing categories are Engineering, Plotting, Mathematics, Education, and Accounting. Other group headings will no doubt be added rapidly. Anyone desiring a set or sets of these write-ups should write the DECUS Office, Maynard, Massachusetts 01754, indicating the category desired. Abstracts of additional routines follow. Each program submitted either to an existing category or as a new category should be submitted with a listing, an example of execution, and a brief abstract which will be printed in this column. We may also reproduce some results of their operation.

This column will serve to disseminate information about modifications to the FOCAL system for special applications. However, the FOCAL program itself and its documentation will be distributed from the DEC program library.

Mathematics

Submitted by: DEC Applications Group

Square Matrix Multiply - The arduous task of multiplying two square matrices is quickly done by this FOCAL Matrix Multiplication routine. The user inputs "N" indicating the number of rows and columns each matrix will have. The computer then requests input of the elements of the two matrices. The result of the multiplication is typed out in an understandable matrix-like format.

Notable characteristics of this program are:

- It is expressed in only five lines of FOCAL script so that it loads quickly.
- It will process matrices of varying dimensions. Size of each matrix is limited only by memory capacity. (In 4K FOCAL the limit is about 6 rows and columns.)
- Because it inputs and outputs the matrix values in a matrix-like format, input transcription errors are less likely to occur.

The readers are invited to investigate the generalization of this algorithm to extend it to the processing of rectangular matrices.

Least Common Multiple (LCM) - The LCM routine is a neat, short program which will compute the LCM of any number of positive integers. Input is in two stages. First, the number "N" of integers is requested. This is followed by the input of the integers.

It is interesting to note that this program actually includes two subroutines. First, in Part 1, the maximum of the set of integers must be found. In Part 2, the actual LCM computation takes place.

This program would probably find its greatest use in classrooms of the lower grades. It could be a tremendous aid to the teaching of fractions.

Base to Base Integer Conversion - The FOCAL Base to Base Conversion routine will convert any positive integer less than 2048 from one base system to another. Such a program would find use in the teaching of high school mathematics where such problems in number theory are encountered. The program does not handle fractions, and it does not check the input number to be sure that all of the digits are allowed in the specified base. Readers are invited to write a more universal conversion routine.

Prime Number Generator - The Prime Number Generator is a program which will accept a number, N, and type out all primes less than that value. As soon as the program is finished, it loops back and starts over again by asking for N.

One use for this program would be found in computer-aided instruction in the lower grades where primes are first encountered.

Repeating Decimal Program - This routine computes the decimal equivalent to any rational number whose absolute value is less than 1. Such a program would be very useful in the teaching of fractions in school. Readers are invited to investigate computations with fractions greater than 1.

Submitted by: R. E. McCullough, University of Colorado

N-th Degree Polynomial Data Point Fitting Routine - This program accepts the x- and y- coordinates for an unlimited number of data points and calculates for the equation

$$Y = A_0 + A_1X + A_2X^2 + \dots + A_NX^N,$$

the coefficients A_N which best fit the equation to the data points. The fitting criterion is "least squares." The program allows the user to select the degree, N, of the fitting equation. N may be as large as 7.

N-th Degree Polynomial Data Point Fitting Routine, with RMS Error - This program is the same as N-th Degree Polynomial Fitting Routine except that it calculates the RMS error between the y-coordinates of the data points and the evaluated fitting equation. It will accept only a limited number of data points and the maximum equation degree allowed is inversely related to this number.

Engineering

Second Order Differential Equation - This is a routine to solve

$\frac{D^2X}{DT^2} - K1 \cdot \frac{DX}{DT} + K2 \cdot X = \emptyset$ given K1, K2, and initial values for X, $\frac{DX}{DT}$, and $\frac{D^2X}{DT^2}$. The user also selects the time interval

DT. The result is plotted on the TTY from time zero until interrupted.

A check is made for off-scale values.

Accounting

Submitted by: G. L. Helgeson, Helgeson Nuclear Services, Inc.

Payroll Calculations - This routine is used to calculate payrolls. It is based on the California State Unemployment Insurance rate of one percent of the gross salary, FICA rate of 4.4 percent of the gross salary, and withholding tax as given in Table 7 on page 21 of Circular E, Publication No. 15 (Rev. May, 1968) of the U.S. Internal Revenue Service.

To use it one identifies the individual by typing his name and social security number with the Teletype on "LOCAL." Then, switching to "LINE" and starting the program, one types a "1" if the individual is single or "2" if he is married. Next, one enters the number of exemptions, then the number of pay periods per year. This is followed by entering the base pay and any premium pay. After this the computer does the rest.

This program could be modified easily to fit the rules of any particular state. If some of the pay ranges would not be used, they could be omitted from the two tables, making more room for other routines, such as providing running totals on gross pay, deductions, and net pay.

LINC AND LINC-8 DELEGATES (Continued from Page 24)

Dr. Alvin M. Revzin
Federal Aviation Administration

Dr. John M. Rhodes
University of New Mexico

Dr. Robert H. Schiffman
University of Missouri

Dr. Robert J. Shofer
Albert Einstein College of Medicine

Garth Thomas
Ohio State University Hospital

James H. Utzerath
Marquette University School of Medicine
C. C. Wilton-Davies
Royal Naval Physiological Laboratory
England

Dr. James Winkelman
Bio-Science Laboratories

FAST LOGARITHMIC CONVERSION FOR DISPLAY OF NUCLEAR DATA

C. A. Burke and H. W. Lefevre
Physics Department
University of Oregon
Eugene, Oregon

The following subroutine for generating a logarithm and scaling it for a ten-bit display results from a comment by Professor Robert Brochers of the University of Wisconsin—"The obvious way to make a fast logarithmic display is to make it linear between binades."

LOGCAL is written for a PDP-7 with extended arithmetic. It generates a characteristic by finding the most significant bit and tacking on the six next most significant bits for use in lieu of a true mantissa. As listed below the routine plots numbers 2^2 or less on the base line and plots 2^{18-1} at full scale on a ten bit display. The maximum deviation from the true logarithm is less than 1% of full scale with sixteen binades on scale. There is, of course, no error for any number with a zero mantissa.

The subroutine is entered with the number to be converted in the accumulator and returns with the logarithm properly scaled for an immediate DYI.

```
LOGCAL,      Ø
              SPA!CLL
              JMP .+11
              CLQ!NORM-25
              RTL
              LMQ
              LACS
              SNA!CMA
              SKP!CLA
              LLS 6
              JMP I LOGCAL
              LRS 13
              TAD (16ØØ)
              JMP I LOGCAL
```

PDP-8 FORTRAN TRICKS

J. Harvey
Communications and Systems, Inc.
Paramus, New Jersey

Type A Format Data

The basic PDP-8 FORTRAN (DEC-08-AFAC) does not allow alphabetic input data. It is possible to read alphabetic text into a format statement with text between quotes, but this has two shortcomings: the input text must be the exact number of characters provided between the format statement quotes, and the FORTRAN program cannot access the characters for testing, sorting, etc.

A very simple machine language patch has been found that lets the program load characters into integer variables as 8-bit numbers. It uses the numbered PAUSE to call short subroutines,

which in turn call input/output routines in the FORTRAN Operating System itself. The subroutines in the operating system perform the basic functions usually needed:

1. Input/Output device determined by switch register setup as for the usual FORTRAN operations.
2. Ignoring of blank tape and line feeds on input.
3. Echoing characters to the Teletype for low-speed input.
4. Automatically appending line feeds to carriage returns on input or output.
5. On input, returning carriage returns not line feeds to the calling programs.

In PAL, the machine patches needed for the operating system of August 15, 1965 (08-AFC3), are:

```

INPUT, 0      /READ A CHARACTER
JMS I 134
DCA NCHAR    /A FORTRAN VARIABLE
JMP I INPUT
OUTPUT, 0     /OUTPUT A CHARACTER
TAD NCHAR
JMS I 153
JMP I OUTPUT

```

Of course, using K. I. Gordon's technique (Letters, Vol. 6, No. 3, of DECUSCOPE) these simple PAL routines can be coded entirely in FORTRAN. The following must be the first part of your FORTRAN:

```

NCHAR = NCHAR
DIMENSION IO(8)
IO(6) = -1700
IO(7) = 1790
IO(8) = -1030
IO(2) = 766
IO(3) = -1685
IO(4) = -1034

```

On execution of a PAUSE 3962, a single character will be read from the keyboard (or high-speed reader if SR selected) and left in the FORTRAN variable NCHAR. On execution of a PAUSE 3958, the right hand 8 bits of the number in NCHAR are sent to the Teletype or punch. A trivial example follows:

```

DIMENSION LETR (200)
DO 3 K = 1, 200
PAUSE 3962

```

- C; A character is in NCHAR. Test it for
C; Control - form feed which is 140 decimal
LETR (K) = NCHAR
IF (NCHAR - 140) 3,5,3
3; CONTINUE
C; Found a form feed or end of buffer
C; Now print buffer
5; K = K-1
DO 6 J = 1, K
NCHAR = LETR(J)
C; A character moved from array to NCHAR
C; will be printed by PAUSE 3958
PAUSE 3958

```

6; CONTINUE
C; Now generate all characters and print
C; Start with a Bell
NCHAR = 135
DO 7 J = 1, 113
PAUSE 3958
NCHAR = NCHAR + 1
7; CONTINUE
STOP
END

```

Direct Access to the DECTape Buffer

The FORTRAN DECTape facility of the 08-AFAC version uses a physical READ or WRITE statement to move 128 word blocks of data between tape and core. A pseudo READ or WRITE moves it in or out of the FORTRAN variables. In some cases, such as reading data from the block, altering it and writing it back on the tape, a physical reread of the block is necessary in order to reset the pointer and allow writing at the buffer beginning. Several lines of coding are required this way. Also, the space lost to the DECTape buffer is sometimes needed. If the buffer could be treated as a FORTRAN array and accessed directly with assignment statements, a considerable space saving and increase in flexibility results. This can be done by using negative subscripts in an array variable.

The DECTape buffer starts at 5600. Using symbol print to locate an array in the program, an offset can be calculated that will result in the subscript actually pointing to the DECTape buffer. Since the operating system does not check the legality of subscript values, this subterfuge works. Any array of the proper type can be used, of course, including one containing active data, since the array name is simply a foundation for the negative subscript. However, for an example a special one word array is declared:

```

DIMENSION KBUF (1)
NOFF = -1022
READ 8, 9, 10
KBUF (3 + NOFF) = 1 + KBUF (3 + NOFF)
WRITE 8, 9, 10
STOP
10; FORMAT (1)
END

```

Element 1 of array KBUF is at 7576 octal and the variable NOFF is set to the negative offset required to point to the tape buffer. Then block 9 of unit 8 is read, the third word in the block incremented by 1 and the block rewritten on unit 8.

The value of NOFF will be different if floating point words are used. For a one-word floating array at 7574, the offset is probably -340 (warning: this writer has not tested floating point operations so the offset value is suspect).

BINARY PUNCH (Digital-8-S-U Sym) MODIFIED FOR LINC-8

Glen W. Johnson
Institute of Oceanography
Dalhousie University
Halifax, Nova Scotia
CANADA

The usefulness of this program can be greatly increased by including it on tape to be read in automatically by the LOAD switch. Furthermore, there is no need for two halts to get the starting and last addresses. By changing the two locations noted below, both switch registers will be used and only one halt made.

Location	Change	
	from	to
7476	7604 (LAS)	6145 (ILES)
7477	-	-
7500	7402 (HLT)	7000 (NOP)

The program usage should now be changed by replacing sections 4.4.3 and 4.4.4 in the write-up with the following:

4.4.3 - The computer will halt. Set the initial address of the block to be punched in the left switches and the final address in the right switches. Press CONTINUE.

Note that now there will be only one halt before each consecutive block is punched.

To put the modified BIN PUNCH on tape, follow these steps:

1. Raise LOAD.
2. Using the BIN LOADER, read in the BIN PUNCH.
3. Make the above changes from the LINC console; i.e.,
in location 3476 put 6145, and
in location 3500 put 7000.
4. DO: WRC (0704) 7/006.

LINC-8 LOAD PROGRAM MODIFICATIONS

The following changes to the LOAD program (DEC-L8-L2AA-D) cause LAP6-3L (DEC configuration) to be read in and started by lifting the LOAD switch. As in the original LOAD, the user may insert his own read commands. If one desires to use the PDP-8 RIM or BIN loaders, there is ample time to press STOP before block 200 is reached.

```
*15      RCG      0701  /LINC COMMANDS TO START
          7/200   7200  LAP6-3L
          /DEPENDS ON CONFIGURA-
          TION USED
          /PDP-8 COMMANDS TO START
```

```
*4111      LINC
          JMP 170 5370
*4170      TAD C15 1377 /SET LINC "P" REGISTER
          ISSP      6165
          TAD M3 1376 /12 IN ACCUMULATOR
          ION       6001
          ICON      6141 /START LINC AT "15"
          NOP       7000
M3,      -3      7775
C15,     15      0015
```

To make these modifications, perform the following steps from the LINC console.

1. LOAD
2. DO: 0700 0002

Check that locations 21, 22, 24, 26, and 175 are zero. The last one is in a PROGOFOP patch to define OPR 0 and OPR 1. Check other patches for program flags which must be zero.

If there are no changes to be made, skip step 3.

3. DO: 0704 0002
4. DO: 0700 0000

Insert the above commands, dropping the leading 4 from the addresses (i.e., insert 5370 in LINC address 111, etc.).

5. DO: 0704 0000

LINC-8 EVENT COUNTER

Up to 256 events can be counted and indicated for the operator's peace of mind while a long program is running. OPR 2 is defined to increment bits 0 to 6 of the PDP-8 accumulator and the link each time the command is given. OPR i 2 resets these bits to zero.

This program assumes that my previous patch to define OPR 0 and OPR 1 is in PROGOFOP. The origin has been set at 2020 to allow the use of bank 1 as a lower memory bank with least interference. Locations required are 25₁₀, but this could be reduced to 15₁₀ by doing without the link bit (count 128 events).

It is suggested that the program be placed on block 7 of tape and the following patch be placed in the LOAD program on block 0.

```
*4071 /location 71 in block 0
          JMS I READIT 4713
          7          0007 /BN
          2000      2000 /initial address for block 7
```


/LINC-8 EVENT COUNTER

LINSTR=31

```

*125      /DISPATCH LOCATION IN PATCH WHICH DEFINES OPR 0 AND 1
          INCRMT          2020

*2020
INCRMT,   TAD LINSTR      1031
          AND C20          0250
          SZA CLA         7640      /I = 1 ?
          JMP RESET       5237      /YES, RESET COUNT = 0
          TAD LIM         1245      /NO, COUNT MORE
          RAR             7010      /RECALL L BIT
          CLA             7200
          TAD I ACCIM     1644      /RECALL REST OF COUNT
          TAD C40         1247      /INCREMENT
          DCA I ACCIM     3644
          RAL             7004
          DCA LIM         3245      /SAVE L BIT
          TAD LIM         1245
          RAR             7010      /RESET L BIT
          JMP I 176       5576      /LOCATION WHICH CONTAINS GOBACK=1460
RESET,    TAD C12         1246      /IN PROGOFOP PATCH
          DCA I ACCIM     3644
          CLL             7100
          DCA LIM         3245
          JMP I 176       5576
ACCIM,    362             0362
LIM,      0               0000
C12,     12              0012
G40,     40              0040
C20,     20              0020
    
```

CHANGES TO FOCAL WHICH ALLOW REFERENCING
THE AF01A MULTIPLEXER AND A-D CONVERTER
WITH FADC FUNCTION

Robert E. McCullough
University of Colorado
Boulder, Colorado

changes listed below will allow either version of FOCAL to reference the Type AF01A Multiplexer and Analog-to-Digital Converter with the FADC function. The argument is the multiplexer channel number in decimal. The value converted has only 11 bits accuracy because of the manner in which the number is handled in the floating accumulator by FOCAL.

The latest version of DEC's FOCAL program (DEC-08-AJAB) and the original version are both written to reference the Type 189 Analog-to-Digital Converter with the function FADC. The

The values generated are from 0.0 to 0.999512 for input voltages of 0 to -10 volts.

```

3203     5604     JMP I 3204
3204     5753     5753
5753     4452     JMS I 0052 /FLOATING TO FIXED CONVERTER
5754     7300     CLL CLA
5755     1045     TAD 0045
5756     6002     IOF
5757     6542     ADSC
5760     7300     CLL CLA
5761     6531     ADSF
5762     5361     JMP. -1
5763     6534     ADRB
5764     7004     RAL      /FIX WHICH GIVES 00008 FOR
5765     7032     CML RTR  /ZERO VOLTS, 37778 FOR -10 VOLTS
5766     6001     ION
5767     5770     JMP I 5770
5770     3214     3214
    
```

A PRE-ANSWERING OPTION FOR LINC-8

QUESTION AND ANSWERING SUBROUTINES

Walter H. Jesteadt
Bioacoustics Laboratory
Eye and Ear Hospital
Pittsburgh, Pennsylvania

Extensive use of the standard Question and Answer subroutine in LINC or LINC-8 data processing programs maximizes flexibility and minimizes the possibility for errors on the part of inexperienced users. The major disadvantage of such a conversational mode is that it requires the continued presence of the user to carry on the conversation, which may be interrupted by long periods of printing results or reading paper tape data.

Use of an alternate Q&A subroutine, called Automatic Control, makes it possible for an experienced user of the program to answer all the questions in advance. In an initialization procedure, the Automatic Control subroutine is read in from LINCtape and the user is asked to type answers to the Q&A's

in the main data program in the order in which he anticipates their occurrence. The answers are stored in a buffer in the subroutine which is then stored on tape.

The main data program uses a sense switch option at every point where the Q&A subroutine would normally be read in from LINCtape to decide whether the Automatic Control subroutine should be read into quarter two instead. Instead of displaying the text specified in the main program, Automatic Control searches for the question mark codes surrounded by 76's and fills these locations sequentially with answers from the list supplied by the user. It returns to the main program after the text.

The exact sequence of instructions required in the main program and for initialization will depend on the nature of the main program itself. Only the listing for the sequential filling of question marks is presented here. It should be noted that the index register cannot be used anywhere in the main program and that the Automatic Control subroutine must be stored again on tape before anything else can be read into quarter two.

	0001	[AUTOMATIC		
	0002	[CONTROL		
	0003	[SUBROUTINE		
	0004	≡1000		
1000	0005	LDA	1000	
1001	0006	0	0000	
1002	0007	BCL i	1560	
1003	0010	6000	6000	
1004	0011	STC 2	4002	/SET 2 AS POINTER TO
1005	0012	#7I LDH i 2	1322	/TEXT IN MAIN PROGRAM
1006	0013	SHD i	1420	
1007	0014	7600	7600	
1010	0015	JMP 4E	7015	/FILL NEXT LOC. FROM LIST
1011	0016	SHD i	1420	
1012	0017	7700	7700	
1013	0020	JMP 5E	7026	
1014	0021	JMP 7I	7005	
1015	0022	#4E LDH i 10	1330	/10 POINTS TO LIST
1016	0023	STH i 2	1362	
1017	0024	LDH i 2	1322	
1020	0025	SHD i	1420	
1021	0026	7600	7600	
1022	0027	JMP 7I	7005	
1023	0030	LDH i 10	1330	
1024	0031	STH 2	1342	
1025	0032	JMP P-6	7017	
1026	0033	#5E LDA	1000	
1027	0034	2	0002	
1030	0035	BCL i	1560	/CLEAR HALF WORD BIT
1031	0036	6000	6000	
1032	0037	ADA i	1120	/ADD JMP CODE AND
1033	0040	6001	6001	/INCREMENT
1034	0041	STC 6E	5035	
1035	0042	#6E 0000	0000	/RETURN TO MAIN PROGRAM

BINARY PUNCH

William Simon
University of Rochester Medical Center
Rochester, New York

Programs for SNAP, the real-time interactive language announced in *Medical & Biological Engineering*, January, 1968, are now available for the solution of up to 14 simultaneous linear equations and for multicompartmental analysis of up to 4 decaying compartments.

SNAP, developed at Harvard Medical School for PDP-8, allows up to 90 real-time, interpretive instructions and up to 200 tabular entries. The usual arithmetic, trigonometric, and logarithmic functions are available. SNAP is compact and easy to learn. For example, a real-time pulse interval histogram can be written in 11 instructions. Typically, beginners with less than 20 minutes of instruction are able to plot functional relationships such as circles, parabolas, and sinusoids. SNAP has been used primarily in a wide variety of biological problems, but is equally suited to many of the problems of engineering and physics which can be done on PDP-8 computers.

Two slightly modified versions of SNAP—ANASNAP and SNAPT—are available from the University of Rochester Medical Center, New York. Both of these use most of the same instructions as SNAP, with the addition, in the case of ANASNAP, of a set of instructions which allow the PDP-8 to simulate an analog computer. The equivalent of an analog integration is performed by a single instruction incorporating automatic time scaling, and up to 12 curves may be displayed by a single instruction. SNAPT (page turning SNAP) allows 180 instructions at the cost of deleting some arithmetic functions.

SNAP, ANASNAP, and SNAPT programs are completely editable in core via the Teletype. No paper tape handling is involved, but programs may be stored on paper tape if desired.

SNAP is available from DECUS for PDP-8's with and without EAE (DECUS No. 8-122), and in a slightly abridged version for LINC-8's (DECUS No. L-31).

RESTART METHOD/PDP-9

William Broadley
Learning Research and Development Center
University of Pittsburgh
Pittsburgh, Pennsylvania

We have been using a method of restarting our 8K paper tape system on our 16K PDP-9 that is simpler than using a system restart program. If the computer has halted, we type a control P, then we start at location 1. An IOPS error will usually occur, but a second control P and a second start at location 1 will usually restart the current system program. We find this sequence especially useful after power up occurs.

SOROBAN CARD READER PDP-9 INTERFACE

Norman Benowitz
Data Systems Division
Hughes Aircraft Company
Culver City, California

An interface between the Soroban Model ERD Card Reader and the PDP-9 has been designed and is operational at Hughes Aircraft Company. Data from the 1100 card-per-minute reader may be transferred through the data channel or to the AC under program control. Use of the data channel allows 80 columns of card data to be placed in consecutive memory locations with a single IOT instruction and eliminates the need for "ready" testing of each column of data. Fewer than 80 columns may be transferred from a card by an appropriate setting of the PDP-9 word count. Data may be read in binary form or translated to BCD (Hollerith) code by interface hardware. Illegal BCD punches are detected by the interface, and a bit is set in the word transferred to indicate this.

Card reader status may be tested by reading an 18-bit status word. An IORS bit and several skip IOT instructions may also be used to determine card reader status. The interface connects the card reader to API and PI. Interrupts include:

- a. the card reader is ready to read the next card,
- b. the word count has reached 0 (indicating the desired number of columns have been transferred), and
- c. trouble exists in card reader hardware.

The card reader interrupts may be individually enabled or disabled in any combination with a single IOT instruction. An IOT instruction allows cards to be offset in the stacker for visual identification. Use of all Soroban features and signals and several additional features is obtained through a versatile interface with 14 principle IOT instructions, plus many micro-coded combinations.

The interface is constructed with DEC R & W Series modules. Fifty-five modules are required.

Software in use and available with the interface includes a PDP-9 Advanced Software System monitor-compatible card reader handler. A version of MACRO-9 allows assembly directly from punched cards.

NEW DECUS PUBLICATIONS

DECUS Program Library Catalog - June 1968

Second Canadian Symposium Proceedings - held at the Skyline Hotel, Ottawa, Ontario, Canada, February, 1968

1968 Spring Symposium Proceedings - symposium held at the Bellevue Stratford Hotel, Philadelphia, April, 1968

1968 DECUS Brochure - description of DECUS, objectives, activities, etc.

LOW-COST MAG TAPE SYSTEM-DATAVOICE 8

J. B. Brown
Betatech, Inc.
Bedford, Massachusetts

Betatech has developed and is offering a low-cost magnetic tape system for the PDP-8 series of computers. The system consists of interface electronics constructed from DEC Flip-Chips and up to four tape decks of the high quality audio type using standard 1/4" tapes. Software with the system includes a relocatable selective dump routine and a load-and-go loader. Presently under development is a set of routines to provide an operating system compatible with Symbolic Tape Editor, PAL III, etc. In addition to recording digital data, the system provides a voice channel in parallel with the data. Operating instructions, program and data identification are conveniently recorded on this channel and often eliminate the need of bringing and referring to bulky documentation.

The DV-8 system has been specifically designed to assist in operations where the main I/O device is the standard Teletype. When storage or input-output requirements are high or the computer is being shared among many users, the high transfer rate of the DV-8 is a welcomed addition to the installation. The entire DEC software for the PDP-8 can be stored on a single tape reel and left mounted ready for immediate recall. Snapshots of crashes and system reloads are quickly performed. Each user can easily keep his entire set of programs (two million characters) on his private tape reel and save partially debugged programs for the next session.

Hardware

The hardware supplied consists of interface electronics and one of several types of audio tape transports. Below is shown a reel-to-reel unit with the manual controls called out. This unit contains three heads on each of two tracks (erase, record, read). The audio track operates in the conventional manner, while a phase modulation type of recording is employed on the data track. At the operating speed of 7 1/2 cps, both channels have a bandwidth of 15 kHz. The record and recovery scheme used on the data track, however, requires only a 4 kHz bandwidth to insure proper performance in a less-than-perfect environment. Both under program control and manually, the tape can be moved in either direction at the operating speed of 7 1/2 cps. Manual controls allow fast forward and fast reverse.

The interface electronics provide a single IOT to control the operation of a tape unit. Each unit, independently, can be commanded to go forward or reverse, read and/or write. In addition, a program-selectable 60 cps interrupt can be enabled to provide accurate motion control timing.

To control data flow, the electronics associated with the Teletype unit is shared with the tape interface. During tape operation, the Teletype printer/punch is held marking, and the keyboard/reader is logically disconnected. After a tape operation, the program returns the Teletype unit to its normal function.

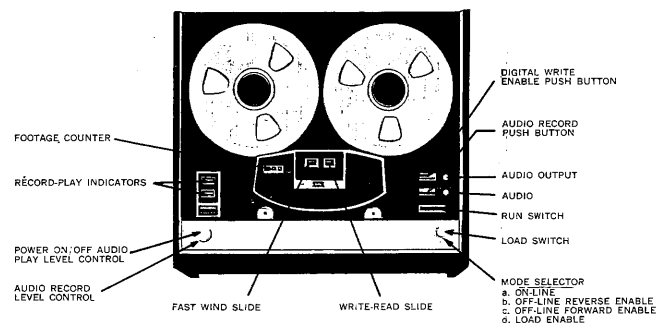
While transferring data to the tape system, the tape unit appears identical to the operation of the Teletype with the exception of transfer speed. Thus the IOT's and interrupts associated with the printer/punch and keyboard/reader are

employed to write and read tape. Being full duplex allows writing and reading on the same unit (read after write) or on different units (source, output). Data can be transferred asynchronously up to 600 characters/sec., and many of the existing Teletype routines can be used directly.

Software

The software included with the system at the present is a relocatable selective dump and a load-and-go loader compatible with the BIN LOADER. An operating system employing the tape system is under development but is a subject of a later DECUS article.

For further information contact: J. B. Brown, Betatech, Inc., Box 345, Bedford, Massachusetts 01730, AC 617, 275-0750.



MODULE USERS GROUP MEMBERS

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Lehigh Valley Electronics, Inc.

Dr. Herman H. Samson
Arizona State University

Ron Southworth
U.S. Plywood

D. R. Thorne
Arizona State University

LETTERS

"Dear Mrs. Cossette:

"Please refer to my letter of April 1, 1968. (Ed. note: Published in DECUSCOPE, Vol. 7, No. 2.) I really didn't intend to send you an April fools joke, however, that's the way the program turned out to be. If the last four instructions are deleted and left as they originally were, the modified Phoenix assembler will compile all the teletype keyboard reader mnemonics. I am sorry for the error. The correct changes are:

<u>ADDRESS</u>	<u>OLD CONTENT</u>	<u>NEW CONTENT</u>
0200	6032	6016
1465	6031	6011
1467	6036	6016

Very truly yours,

HELGESON NUCLEAR SERVICES, INC.

Geo. Lewis Helgeson
President"
872 Abbie Street
Pleasanton, California 94566

"DECUS,

"I am planning to work on a SNOBOL4-Interpreter for the PDP-8.

"I would like to know whether someone:
. has worked on it;
or . is working on it;
or . is planning to work on it.

Andre M. Gagnoud
CIDS Project
3625 Walnut Street
University of Pennsylvania"
Philadelphia, Pennsylvania 19104

"Dear Mrs. Cossette:

"I would like to thank Messrs Griffin of Ontario Hydro and Gordon of DEC for their comments on my note on negative input level conversion published in DECUSCOPE, Vol. 7, No. 1.

"I agree with their comments entirely. In my note I, in fact, tried to point out a general method for level conversion. Perhaps I should not have used DEC modules as an example.

Yours faithfully,

R. Krishna
Department of Electrical Engineering"
University of Saskatchewan
Saskatoon, Saskatchewan, Canada

"Dear Mrs. Cossette:

"We at Lamont Geological Observatory are very interested in obtaining Calcomp Plotter software for our PDP-8. We would appreciate it if you could send us any information on available DEC or DECUS software.

"We would also like to correspond with anyone else interested in the development of plotter subroutines along lines similar to those of the IBM 1130/1800 plotter subroutines.

Sincerely,

Herbert Poppe"
Lamont Geological Observatory of Columbia University
Palisades, New York 10964

"Dear Mrs. Cossette:

"This is to draw attention to a small "bug" in the LINC-8 LIBRARY system. This is in the binary paper tape loader segment, which is called into core memory following the command ESCAPE or when any user program is called. The bug is that, if the binary loader encounters an origin setting which is not followed by any data before the next origin setting, then the location corresponding to the first origin setting is cleared to zero. This is of practical importance because PAL III punches an assumed origin at location 200 at the head of every tape it outputs, whether or not the symbolic tape specifies anything at location 200. Thus, if the loader is used to read in, e.g., binary subroutines for a FORTRAN program, the main program will be corrupted due to the loss of the contents of register 200.

"I have not attempted to cure the bug by altering the loader program (which is obviously tight for space); it would also, I think, be difficult to suppress the initial origin 200 punch by PAL III; probably the easiest "fix," once one is aware of the trouble, is to make a habit of always assigning location 200 appropriately on every binary tape to be used in conjunction with Library. In the case of FORTRAN subroutines, this requires

*200

SKP CLA

Yours sincerely,

G. R. Hervey"
The School of Medicine
University of Leeds
Leeds, England

WANTED

Information regarding the existence of a PDP-9 Assembler which will produce object code for the PDP-8.

Please send details to the DECUS Office.

NEW DECUS MEMBERS

PDP-5 DELEGATES

Edward O. Adams
Harvey Alumina V.I., Inc.
Virgin Islands

(Miss) Vivienne I. Burton
The Broken Hill Proprietary
Company, Ltd.
Australia

Terence Meehan
Brookhaven National Laboratory

J. F. Petersack
Esso Research and Engineering Company

PDP-7 DELEGATES

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White Sands Missile Range

Dale Barbour
Naval Underwater Weapons Station

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Edward S. Johnson
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Ken Johnson
The Daily Sentinel

J. A. Jones
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Georgia Institute of Technology

Wilfrid L. Lord
Argonne National Laboratory

Paul Mackie
Georgia Institute of Technology

Bernard E. Martin
University of Pittsburgh

Gerald Masek
Presbyterian-St. Lukes Hospital

T. J. McAvoy
University of Massachusetts

Manley L. McCorkle
Pan American Petroleum Corporation

PDP-8 DELEGATES (Continued)

O. D. McIlroy
Springfield Newspapers, Inc.

George Moore, Ph.D.
University of Southern California

Dr. Karl Munkelt
Deutsches Hydrographisches Institut
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PDP-8/I DELEGATES

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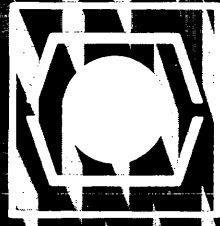
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DECUS FALL SYMPOSIUM

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JACK TAR HOTEL
San Francisco

DEC. 12,13,14,
1968

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This issue of DECUSCOPE is a special meeting issue devoted exclusively to abstracts of papers which will be presented at the forthcoming Fall 1968 DECUS Symposium to be held on December 12-14 at the Jack Tar Hotel, San Francisco, California.

All articles originally scheduled for this issue will be published in Volume 7, Number 5.

Registration information and programs have been sent to DECUS members and non-members. Additional copies are available from the DECUS Office in Maynard, or you may register at the Jack Tar during the meeting.

Abstracts are listed by sessions and alphabetically by author within the sessions. Asterisk in author line indicates speaker.

ABSTRACTS

GENERAL SESSION

A COMPUTER WITH HAND, FEET, AND SOUL

Lester Ernest, Stanford University, Stanford, California

Activities of the Stanford Artificial Intelligence Project will be sampled, including hand-eye system, a computer controlled cart, and a music synthesizer.

COMPUTER-ASSISTED INSTRUCTION

Patrick Suppes, Stanford University, Stanford, California

This paper will review the development of programs in computer-assisted instruction at Stanford since early 1963. Detailed examples of curriculum material will be presented as well as an overview of the computer system used, beginning with the PDP-1 and moving to the present PDP-10 configuration. Some forecasts of future developments will be attempted, with special reference to some of the unsolved problems that need solution.

DATA ACQUISITION AND CONTROL SESSION

COMPUTER CONTROLLED TIRE FORCE ANALYSIS SYSTEM

Richard A. Cabot, S. Sterling Company, Southfield, Michigan

A machine control system has been developed for a 4K PDP-8 computer, model ASR-33 Teletype, and DF32 Disc file to control, analyze, and alter the force characteristics of passenger car tires. The system provides many of the characteristics of large scale time-sharing systems while avoiding much of the programming complexity required in such systems. The control features of the system include the ability to execute operator initiated "macro" commands in an on-line mode or in a batch mode. The analysis features of the system range from storage of digitized data records on the DF32 Disc file to the computation of Fourier coefficients using the recently developed Fast Fourier Transform techniques.

A SYSTEM FOR ON-LINE COLLECTION OF REPETITIVE DATA USING THE PDP-8/S

C. Douglas Creelman, Department of Psychology, University of Toronto, Toronto, Ontario, Canada

This paper describes a simple interface and associated software which enable easy control over the timing and

order of events within an experiment. The computer runs experiments under control of an external clock, operating through the program interrupt. An important feature of the operating system is rapid response to a clock interrupt, so that timing of events can be quite precise even with the relatively slow instruction speed of the PDP-8/S. The system was designed so a number of experimenters can each run his own study with quick transition from one setup to another. Current application is in a psycholacoustic laboratory in which human observers are run in different experiments on a wide range of detection and discrimination tasks. The currently operating experimental compiler and operating system (PSYCLE) will be outlined, and possible extensions to other fields will be considered.

THE USE OF A COMPUTER FOR AUTOMATIC GAGING AND CONTROL

Nanlal K. Desai, Bendix A & M Division, Dayton, Ohio

A digital computer can be used on line as a stored program controller for automatic gaging for transfer type of machine. The application described here consists of a transfer type of gaging machine handling about 3,000 parts per hour. LVDT analog signals for length, diameter, and squareness from gaging stations are furnished to analog-to-digital converter. The computer samples these informations and stores them in the core. A bad or good part is identified by the computer by comparing with preset nominal values. Bad parts are rejected by the computer and good parts are stacked according to preset information. The computer also keeps record of the material utilized for making parts and material still in process, and it records the information pertaining to the parts on a strip chart recorder for trend analysis.

A COMPUTER-BASED SYSTEM FOR DATA ACQUISITION AND ANALYSIS FROM MULTIPLE GAS CHROMATOGRAPHS

Brad Dewey* and Gary Cole, Digital Equipment Corporation, Maynard, Massachusetts

DEC's new GasChrom-8 System will be discussed. This system automatically detects peaks and shoulders, calculates peak areas and peak retention times, adjusts for baseline shift, allocates overlapping peak areas, identifies components, applies response factors, calculates component concentrations by either internal standard external or area normalization, and types a complete analysis report. The system is capable of performing these functions for up to 20 gas chromatographs simultaneously.

A DATA ACQUISITION AND REDUCTION SYSTEM FOR NMR SPECTROSCOPY

Brad Dewey* and Charles Spector, Digital Equipment Corporation, Maynard, Massachusetts

DEC's new NMR-8 System for automatic data acquisition analysis and control from an MNR spectrometer will be discussed. The system has such features as sweep control, time averaging, scope display, integration, plotter control, and the ability to assist in the analysis through the calculation of relative peak intensities, peak position in units of chemical shift, resolution enhancement, spectral comparison, fourier transformation and analysis, etc. In addition, the NMR-8 can set up and control the magnetic field homogeneity of the instrument.

SOFTWARE FOR A PDP-8 PULSE HEIGHT ANALYZER SYSTEM

W. J. Edwards, General Chemistry Branch, Atomic Energy of Canada Limited, Chalk River, Ontario, Canada

A set of two programs is described which enable a 4K PDP-8 to serve as a versatile data collection and presentation device for γ -Spectrometry. The programs are paper tape oriented and controlled by keyboard commands through a simple executive.

The first program carries out data collection from external, 1024 channel, analog-to-digital converters, and provides various enquiry features for the experimenter to check the progress of the measurements. The output data tapes from the first program are accepted by the second program for automatic and unattended production of hard copy (graphical and/or typed).

THE USE OF THE PDP-8 IN AUTOMATED TEST SYSTEMS AT SANDIA LABORATORIES

Glenn Elliott, Sandia Corporation, Albuquerque, New Mexico

The PDP-8 series of computers is being used frequently in automated test systems at Sandia Laboratory. Several system configurations are presented briefly. Emphasis is placed upon the solution of general problems arising from their use in a large organization of design engineers and in application where delivery schedule time scales are very short. General interfacing methods are discussed and a semi-modular approach is shown. Sandia's method of obtaining programs from an engineering organization where no programming talent previously existed is presented.

LEXIGRAPH, AN INTERPRETIVE LANGUAGE FOR GRAPHICS

Dr. Daniel M. Forsyth*, Psychology Department, University of Vermont, Burlington, Vermont, and

Wynn Fowler, Psychology Department, Harvard University, Cambridge, Massachusetts

LEXIGRAPH is an interpretive language which places a display system and various peripherals in the hands of researchers unfamiliar with low-level languages. The interpreter accepts as input a "script" from paper tape or DECtape. The user may specify the display of text or arbitrary figures defined in the script. A wide range of script commands have been implemented. Presentation and inter-presentation times are controlled (with millisecond accuracy), and chains of displays may be generated which run off without intervening instructions. When display segments (texts or figures) are grouped in lists or strings, attributes of the individual segments (intensity, origin, etc.) may be varied selectively.

Subject responses may be recorded via a response box tied to the information collector, from a Teletype, or by way of a light pen. Acceptable responses or response patterns are defined in the input script. Logical testing of responses is provided for, and full branching capabilities are included. Data (e.g., name of response key and reaction time) are recorded automatically and stored on DECtape and may be punched onto paper tape for off-line listing at the conclusion of an experiment. The script can also direct the opening and closing of selected bits in the relay buffer. This may be used, for example, to control a remotely located audio tape recorder, recording subject responses at arbitrary intervals.

The interpreter has been used by behavioral scientists in a number of areas such as: short-term memory, psycholinguistics, concept formation, visual perception, etc. Operational for two years, it has undergone continuous evaluation and improvement and appears ready for general use.

"SCHLEP" A REAL TIME DATA ACQUISITION PROGRAM FOR MAGNETO-STRICTIVE SPARK CHAMBERS

Michael D. Greenblatt, David Rittenhouse Laboratory, University of Pennsylvania, Philadelphia, Pennsylvania

Schlep is a program which receives data from magnetostrictive spark chambers, condenses, writes on tape, makes decisions, analyzes, and displays this data. The experiment in which this program will participate is the study of the K^0 long lived meson. Its principle service is to aid in the debugging and maintenance of the spark chamber system, but it also serves as a quick way to throughput large amounts of data. It also will make quick and valuable decisions as to the validity of the event and, in a low-priority background, will do some analyzing.

A VOLTAGE INTEGRATOR INTERFACE WITH COMPUTER RESET

Stan Hubler, RCA, EASD, Van Nuys, California

An integrator is described which acts as an analog memory to accumulate and store activity on an analog input of a LINC-8 during the relatively long intervals between the short sampling periods. The integrator is reset to zero immediately after it is sampled by the computer. This is accomplished with a simple hardware addition to the computer, which is also described. Four of these integrators are used in conjunction with an averaging program, AVG 2, similar to AVG 1, previously described by Richard Harshman and Peter Ladefoged in the November, 1967, DECUS Proceedings.

ON-LINE DATA REDUCTION FROM CARY 14, 15, AND 60 SPECTROMETERS

Martin S. Itzkowitz* and Barrett L. Tomlinson, Department of Chemistry, University of California, Berkeley, California

A 4K PDP-8/S computer with ASR-33 Teletype has been installed in this laboratory as the heart of an on-line data reduction system for the Cary 14, 15, and 60 spectrometers. Data flow is from the spectrometer through a set of Datex mechanical encoders through an interface designed to our specifications by Berkeley Scientific Laboratories through the computer and onto the Teletype both as printout and binary punchout. The software system includes a rapid averaging algorithm to eliminate high-frequency noise, a sliding thirteen point least-squares curve fitting, a fully buffered I/O system and a versatile monitor which virtually eliminates the possibility of unrecoverable operator error.

A PROGRAMMED CONTROL AND INSTRUMENTATION SYSTEM FOR A NUCLEAR REACTOR

J. R. Kosorok, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington

A DEC PDP-7 has been interfaced with a nuclear reactor instrumentation and control system. The test reactor's electric heating system, rated at 384 kW, can heat it to 1000°C. Its graphite moderator is blanketed with pressurized nitrogen to inhibit oxidation. The digital computer directly controls the nitrogen and heating systems and provides operational aids for the reactor personnel. The central processor has 8K words of core storage and utilizes three DECTapes for bulk storage. In addition to the digital control hardware for over 100 analog and 190 digital inputs, two unique features are a three-color, alpha-numeric display and two six-decade analog-to-digital converter channels.

Eleven closed loops were controlled with a digital simulation of a proportional-plus-integral controller, which

was modified to provide several notable features:

1. aids in controller adjustment,
2. transducer signal conditioning, and
3. compensation for process nonlinearities.

Other features of the control system reduce operator errors during start-up and operation of the nitrogen and heat systems.

The complete programmed system is composed of a highly integrated set of executive control, input/output and functional routines which perform the above mentioned control and assist the operator during nuclear operations.

ON-LINE NAVIGATION AND DATA LOGGING FOR THE MPL DEEP TOW

Dr. Carl D. Lowenstein, Marine Physical Laboratory, Scripps Institution of Oceanography, San Diego, California

The growth of a PDP-8 system used in conjunction with a towed oceanographic instrument package is described. The Deep Tow instrument carries sonar systems which measure its distance from the surface and from the bottom of the ocean, as well as its distance from several acoustic transponders fixed on the bottom. In addition, the Earth's magnetic field and the water temperature are measured at intervals. This data is telemetered to the towing ship and recorded there. The computer, as directed from the keyboard, performs calculations on the transponder data to provide a position fix and plots this fix on an X-Y plotter when commanded. Simultaneously, in a background mode controlled by interrupts, the computer is gathering other sonar data, reading the magnetometer and temperature systems, processing this data, and logging it on punched paper tape.

Several interfaces have been built to make the automatic data gathering possible, they will be described briefly. Software problems which have arisen during the operation of these two independent but simultaneous systems will be discussed, together with possible hardware additions to make the programmer's task easier.

A PDP-8/S AS A PROCESS-TESTING CONTROLLER FOR MANUFACTURE OF TANTALUM THIN-FILM T-PAD ATTENUATORS

H. D. Marshall* and R. L. Siegel, Western Electric Company, Inc., Allentown, Pennsylvania

A PDP-8/S forms the nucleus of a complex anodizer-tester for the manufacture of T-Pad Attenuators. This paper describes the basic problems of anodizing and testing tantalum resistors and the design consideration of hardware and software to meet this task. The hardware coverage in this discussion is limited to basic descriptions of the peripheral equipment to allow a more thorough treatment of the Software Logic.

WEATHER AND A PDP-8/S

T. McGovern* and R. E. Archinuk, Assessment, Computing and Instrumentation Branch, Atomic Energy of Canada Ltd., Pinawa, Manitoba, Canada

The meteorological system at Whiteshell Nuclear Research Establishment includes several instruments for measuring wind speed, wind direction, temperature and solar radiation. The instruments were interfaced with a PDP-8/S computer to obtain the data in real time. The data was processed to give mean values over a 10-minute interval once per hour. The results were printed and punched in a code suitable for further analysis in the computer center. The problems encountered before and after installation are discussed.

DATA ACQUISITION AND CONTROL OF A SPECTROPHOTOFUORIMETER

Robert H. McKay*, Frank Neu, and Myron Myers, Department of Biochemistry and Biophysics, University of Hawaii, Honolulu, Hawaii

An interface between a spectrophotofluorimeter built in this laboratory and a standard PDP-8/S computer will be described. The interface utilizes DEC modules, stepper motors for wavelength and polarizer positioning, and a Hewlett-Packard #2401-C Integrating Digital Voltmeter for data acquisition. Light source fluctuations are controlled using a monitor on the incident light, a v-f converter, and feeding this in as an external time base for the DVM.

Software developed for this application will also be described briefly.

The instrument is capable of plotting either corrected fluorescence excitation or polarization spectra, with a data collection interval as low as 0.5 μ s.

AUTOMATED ALPHA PULSE ANALYSIS - PART II*

G. G. McMillan* and J. E. Evans, Lawrence Radiation Laboratory, University of California, Livermore, California

A computer program has been written to control the accumulation of alpha particle spectra by several pulse height analyzers. This program was written specifically for a 4K PDP-8. The computer is equipped with DECTape, an ASR-33 Teletype, an IBM 526 Card Punch, and one to four Nuclear Data ND-130 Pulse Height Analyzers. Each pulse height analyzer contains 512 channels that are split into four quadrants of 128 channels each. Each quadrant is equipped with a six-position automatic sample changer, thus as many as 96 samples can be programmed for spectral analysis. Significant features of the program include the acceptance of identification and control information from the Teletype, rotation of the sample changer to the correct position, periodic integration of

the α -spectra, and recording each spectrum on DECTape and IBM cards when it is found to be statistically valid.

*This work was performed under the auspices of the U.S. Atomic Energy Commission.

THE PRINTING DENSITY ANALYZER: A SYSTEM FOR PROCESS CONTROL

William A. Minnick* and Charles M. Stasey, Itek Corporation, Lexington, Massachusetts

The printing density analyzer is a system designed to rapidly scan photographic film to determine emulsion density characteristics needed for the duplication printing process. The system data acquisition and function control problems lend themselves to an elegant solution through the implementation of a small general-purpose digital computer (PDP-8/I).

The authors discuss a general software approach to the development of this real time, interrupt-driven system. Solutions to specific hardware and software problems will be discussed and results will be demonstrated. The paper will conclude with a discussion of the management approach employed to minimize the final cost of programming and implementing the computer into the system.

A MULTI-STATION DATA ACQUISITION AND CONTROL SYSTEM

Thomas H. Rau* and Howard Borer, The Dikewood Corporation, Albuquerque, New Mexico

The presentation is broken into three major sections:

- A. System Design and Control - Covering the basic system design, creation of the system in a "fresh-start" situation, and the overall system control operation.
- B. Multi-station Data Acquisition - Covering the data acquisition process, optional interrupt processes, reformatted data-storage, and restart capability.
- C. Data Reduction (Quality Control) - Covering report generation, data history file creation, data control information changes, and system shut down.

A MODULAR ANALOG DIGITAL INPUT SYSTEM (ADIOS) FOR ON-LINE COMPUTERS

D.A.H. Robinson*, R. W. Kerr, H. P. Lie, and G. L. Miller, Bell Telephone Laboratories, Inc., Murray Hill, New Jersey

A system is described which is designed to permit the user of an on-line computer to achieve a desired hardware configuration with a high degree of flexibility. The system uses modular plug-in units inserted in bins which are interconnected by a common two-way analog and digital data bus. The system is designed for a PDP-8 computer and can be expanded, as needed, to handle up to 60 modules.

The modules, which were designed to provide a simple,

low cost means of analog and digital measurement and control, are of four types. These are a digital input-output register, a scaler, a relay bank, and a power supply. The design of the modules takes advantage of the versatility of the computer in a number of ways, including provisions to allow the computer to check each module for proper operation.

Several system configurations are described. Included are examples of the use of the system to automate such things as the testing of spacecraft experimental hardware, and the measurement of Hall effect coefficients over an extended temperature range.

(This paper will also be presented at a session of the FJCC on Laboratory Automation.)

EXPO, A FLEXIBLE PDP-8 DATA-ACQUISITION PROGRAM

Bruce Arne Sherwood, Synchrotron Laboratory,
California Institute of Technology, Pasadena, California

EXPO is a program for a 4K PDP-8 with EAE which reads various kinds of data from experimental apparatus, optionally logs data on magnetic tape, and accumulates one- or two-dimensional histograms of selected variables. From the Teletype keyboard the user defines which variables are to be histogrammed and under what conditions; variable names are four-letter mnemonics and numerical parameters are decimal. Also, from the keyboard the user may call for Teletype or scope output of histograms with some control of format; output may occur simultaneously with data acquisition. EXPO proved very useful in a high-energy physics experiment and may have wider applicability.

REAL TIME ACQUISITION AND DISPLAY OF MASS SPECTRA

P. D. Siemens, Lawrence Radiation Laboratory,
University of California, Livermore, California

A program package has been developed to perform real time data acquisition and display from a mass spectrometer. In this particular case the data acquisition routine performs multiumming-scaling; but, with minor changes, the package could do signal averaging or pulse height analysis.

Through a keyboard monitor, the operator has complete control of the experiment with a variety of commands available to him. Among these are commands which provide for: control of the data acquisition, real time log or linear displays, data output on paper tape, Teletype, DECTape, or Calcomp, and data reduction (peak stripping and the calculation of isotope ratios).

VIDAC - A DATA ACQUISITION PROGRAM

Robert W. Skyles* and Noel P. Lyons, VIDAR
Corporation, Mountain View, California

VIDAC is a data acquisition system program for the non-sophisticated computer user. Its features include

flexibility of subroutine usage, a linking loader, and an easily modified executive routine.

A presentation of the hardware and software parameters considered in establishing a computer-controlled data acquisition system for general purpose use will be given.

A description of how VIDAC meets these requirements, followed by three specific examples of VIDAC's use encompassing widely varying data acquisition requirements, will be presented.

A FLEXIBLE DATA ACQUISITION AND CONTROL SYSTEM UTILIZING A PDP-8/S

G. E. Stokes* and D. R. Staples, Idaho Nuclear
Corporation, Idaho Falls, Idaho

A multi-scaler data acquisition system with sensing and feedback controls to the experimental devices has been designed around a PDP-8/S computer. This system has been used on a number of experiments with a variety of control requirements. In each case the configuration was integrated into the experimental setup with a minimum of hardware changes. The computer interface includes four 12 bit scalers, a real time clock, a 10 bit ADC, a 6 bit relay divider, pulse generators for driving pulsed motors, and a 10 bit DAC. The interface will be described and techniques for programming the device for different experimental requirements will be discussed.

COMPUTER CONTROL OF HYDRAULIC TESTS

L. A. Thomas, New Brunswick Research and Productivity
Council, Fredericton, New Brunswick, Canada

This paper describes the use of a PDP-8/S computer in obtaining the characteristics of hydraulic pumps, motors, and transmission systems. The aim of this work is to provide a rapid and accurate method for carrying out such tests.

Some of the interface problems, methods of handling the data, and programming techniques which are peculiar to this type of system are discussed.

A programming language has been written, making use of macros and an operating system, which provides the user with a powerful test, control, and data acquisition system.

QUEUE STRUCTURES IN A PDP-9 DATA ACQUISITION SYSTEM

Barry L. Wolfe* and Sol B. Metz, Information
Control Systems, Inc., Ann Arbor, Michigan

The paper describes methods of implementation of a data acquisition system in a manufacturing environment on an 8K PDP-9 with DECTapes. The system maintains piece counts and updates production schedules, logs production equipment, states changes, reports exception conditions, and processes real-time inquiries. The system utilizes queue structure for in-process data in order to conserve and dynamically allocate core storage.

EDUCATION SESSION

A GENERALIZATION OF COMPUTER-ASSISTED INSTRUCTION

Dr. Ludwig Braun, Polytechnic Institute of Brooklyn, Brooklyn, New York

A description is given of the Huntington Computer Project, its objectives, and its methods of operation. Its objectives are:

1. To explore the potential impact of the computer on learning in high school courses in biology, chemistry, mathematics, physics, and social studies. In this project, the computer is used as a high-flexible laboratory rather than as a "programmed-instrumental" device.
2. To explore the relative merits of time-shared and stand-alone computing.
3. To attempt to determine the differential effect, if any, of socio-economic condition on the learning experience of participating students.

Some of the programs already written and under development are described.

A compiler and operating system which implements the full capability of BASIC on a PDP-8/I is described.

CAI APPLICATION AT STANFORD

Dow Brian, Institute of Mathematical Studies in the Social Sciences, Stanford University, Stanford, California

This paper describes the system configuration designed to run several hundred Teletype terminals in computer-assisted instruction. Particular emphasis is given to the method of generating audio output. Many CAI applications, such as elementary reading and foreign language, require computer-controlled speech to be maximally effective.

A vocabulary is constructed by digitizing individual words and storing them on a disk file. Messages are then constructed in real-time by outputting sequences of words through a specially constructed digital-to-analog multiplexer channel. The system resources and software necessary to operate 72 audio stations simultaneously with other CAI and time sharing activities are described in detail.

THE COMPLETE COMPUTER ENGINEERING LABORATORY

Fred F. Coury, Department of Electrical Engineering, University of Michigan, Ann Arbor, Michigan

This paper describes a laboratory facility currently in use at the Department of Electrical Engineering, University of Michigan. This facility provides for a wide range of

laboratory experiments and research into many aspects of digital computer engineering.

Equipment available includes small-scale digital computers, analog computers, logic labs, and data sets. The laboratory also contains two unique devices interfaced to a PDP-8. They are the "Micro-8" (a device for external control of PDP-8 internal micro-operations) and a powerful patchboard-oriented logic breadboard device.

Also described is the method by which this equipment is integrated with a sequence of computer engineering courses offered in the Department to provide extensive laboratory experience in such areas as small computer programming (PDP-8 and LINC-8), computer organization and operation (Micro-8), logical design (logic labs and special patchboard device), and hybrid computer systems (LINC-8/AD-24).

THE "MICRO-8"

Fred F. Coury, Department of Electrical Engineering, University of Michigan, Ann Arbor, Michigan

The "Micro-8" is a device designed to demonstrate and provide insight into the detailed internal operation of a digital computer, specifically a PDP-8. It consists of a pushbutton control panel, minimal internal circuitry, connecting cables, and wiring additions to a standard PDP-8.

The pushbuttons are so arranged on an illustrated front panel, outlining the major functional blocks of the PDP-8, that they show the micro-operations which can be performed on and between the various blocks. Pushing the appropriate button causes the desired operation to be performed actually within the PDP-8.

Toggle switch registers simulate data input buses, and the results of an operation are visible in the PDP-8 console indicators. External logic can be used in place of the pushbuttons, allowing student-designed control units to manipulate the PDP-8 registers.

When the "Micro-8" is disabled, it has no effect on the standard operation of the PDP-8 to which it is connected.

A PATCHBOARD-ORIENTED DIGITAL LOGIC BREADBOARD

Fred F. Coury, Department of Electrical Engineering, University of Michigan, Ann Arbor, Michigan

This paper describes a prototype patchboard breadboarding device currently in use at the Department of Electrical Engineering, University of Michigan. The purpose of the device is to allow students to carry on advanced digital design projects in parallel and with minimal equipment expenditure.

The patchboard-oriented device can be compared, in principle, to a standard DEC Logic Lab but is much more powerful in many respects. It provides many more

available module positions, a much greater range of support functions, a greatly expanded control panel, access to all standard PDP-8 I/O lines and "Micro-8" control lines.

The principal difference, however, is that all of these signals are mapped into a 34 by 66 pin patchboard receptacle. This allows for off-line wiring of several devices on removable patchboards and time sharing of the main facility for on-line debugging and demonstration.

Devices built using this facility are described, and an extension of the patchboard concept is discussed.

A LIMITED MULTI-TERMINAL SYSTEM FOR CAI

David A. Ensor, Department of Computer Applications, The Ontario Institute for Studies in Education, Toronto, Ontario, Canada

The paper describes a suite of PDP-9 programs to provide a multi-terminal "CAI" facility for both laboratory experimental use and also to give interested school boards the opportunity for some on-line experience. The OISE configuration is briefly outlined, and both the author language and its processors are discussed in addition to the multi-access software and the batch-time system. It is hoped eventually to run up to 64 terminals through a line concentrator with the system as a foreground program under the Advanced Software System.

LOGO - A PROGRAMMING LANGUAGE FOR CHILDREN, TEACHERS, AND MATHEMATICIANS

Wallace Feurzeig, Bolt Beranek and Newman, Cambridge, Massachusetts

Logo was expressly designed as the starting point for a new kind of curriculum in which programming languages are used to provide a conceptual framework for the teaching of mathematics. The structure of Logo embodies mathematically important ideas with minimal interference from programming conventions. It permits the expression of mathematically rich non-numerical algorithms as well as numerical ones. It can be introduced to third-graders, for simple tasks, with relative ease. Carried forward, it may contribute markedly toward increasing literacy in the skills of logical thinking and expression.

PATTERN AND RATE OF CONVERGENCE OF THE PERTURBATION TECHNIQUE IN THE TREATMENT OF LINEAR AND NONLINEAR PLATE PROBLEMS

Dr. S. F. Ng, Department of Civil Engineering, University of Ottawa, Ottawa, Ontario, Canada

An approximate method based on the Perturbation technique is used to solve the small and large deflection problems of the bending of circular, elliptical and skewed plates resting on an elastic support. The influence of the variable parameters such as the plate aspect ratio, skew angle, poisson's ratio and foundation modulus on the pattern of convergence

is investigated. The algorithm of the solutions and the manipulations of the matrix equations are programmed utilizing direct access devices. Results of this investigation indicate that the rate of convergence of the method decreases rather rapidly with increase in the number of variable parameters both in the linear and nonlinear theory of plates. Results showing the effect of each of the plate parameters on the rate and pattern of convergence are plotted graphically.

CONVERSATIONAL BASIC ON THE PDP-8 LINE

Bud R. Pembroke and Dave Gillette, Computer Instruction NETWORK, Salem, Oregon

This paper will concern itself with the use of CINET-BASIC in the classroom. It will include sample problems and a discussion of the variations between this BASIC and other existing BASIC languages. CINET-BASIC (Computer Instruction NETWORK's BASIC) was written using FOCAL's subroutines for the standard PDP-8 series with 4K memory and ASR-33 Teletype.

Panel Discussion

TRAUMA INVOLVED IN STARTING A NEW COMPUTER SCIENCE PROGRAM AT A UNIVERSITY

Dr. Wayne A. Muth, Moderator
Southern Illinois University, Carbondale, Illinois

Discussion would include curriculum and program requirements; options and/or electives within a program; Ph.D. vs. M.S. vs. V.S. vs. two-year technical programs (trade-offs and considerations); staffing requirements; interaction with other departments; startup of a new program using available personnel, courses, and other resources.

BIOMEDICAL SESSION

ARBUS - AUTOMATED RESERVATION AND BED UTILIZATION SYSTEM

Robert P. Abbott* and Judith Ford, Research Data Facility of the Pacific Medical Center and the Institute of Medical Sciences, San Francisco, California

ARBUS was originally designed to meet the two specific hospital needs as implied in the name. Subsequently, the goals were modified to include other scheduling, inventory, and communication needs within the hospital environment. The system employs the concept of a small computer at the hospital site with a communication link to a larger computer located elsewhere. Terminals located throughout the hospital are connected to a small computer—the PDP-8.

DIAGNOSTIC USES OF AVERAGED EVOKED POTENTIAL IN CLINICAL NEUROPSYCHIATRY

Dr. Enoch Callaway, Langley Porter Neuropsychiatric Institute, San Francisco, California

Over the past four or five years, small high-speed digital computers have been used to process human brain waves in a variety of ways that have potential clinical value. The usual procedure has been to digitize a set of potentials from the head and treat these by a variety of techniques—the most popular of which is averaging sequences of potentials with each sequence having the same time relation to some recurrent event. These averages, frequently referred to as Averaged Evoked Potentials or AEP's, have been put to a variety of uses. The purpose of this paper is to review some of these uses.

LIFE WITH A LABORATORY COMPUTER SYSTEM

Irwin R. Etter, The Mason Clinic, Seattle, Washington

The Laboratory of the Mason Clinic and Virginia Mason Hospital has used a totally dedicated computer system for the past two and a half years. During that time the laboratory staff has become highly dependent on the functioning of the computer. Despite great increases in work load in the laboratory, the size of the staff has been held constant, with a decrease in direct line personnel. The use of the computer allows the staff to pay greater attention to the technical aspects of the laboratory while the computer handles an ever growing portion of the clerical chores. The role of the computer is continually being modified as our experience increases. These changes are due to both the technical changes in the laboratory and to revision of our concepts of the role of the computer. The success of our program is due to the high reliability of the computer system as well as the widespread interest in data processing among the staff.

USE OF A PDP-8/S COMPUTER FOR ON-LINE MONITORING AND CONTROL OF BLOOD GLUCOSE IN HUMAN SUBJECTS

Arnold Henry Kadish, M.D.* and Robert L. Litle, Ph.D., Cedars Sinai Medical Center Research Institute, Los Angeles, California

During the past several years, a continuous monitor for blood glucose has been used to study the response of human subjects to various inputs thus providing data for modeling the human homeostatic system. Recently, a PDP-8/S computer has been incorporated into the system making possible on-line reduction of the data. In addition, a control system has been developed whereby computer derived control signals regulate glucose infusion rates to the subject. This has made possible more detailed studies of human natural control mechanisms.

SIMULTANEOUS FILE PROCESSING AND PATIENT MONITORING WITH A PDP-8/I

M. J. McKeown* and R. Bush, Department of Obstetrics and Gynecology, The Chicago Lying-In Hospital, Chicago, Illinois

There is increasing recognition that one of the more effective ways to fully utilize the capabilities of the large versatile third-generation computers is with local small processors for data concentration and transmission.

The Chicago Lying-In Hospital is investigating the effectiveness of automated data processing in improving prenatal care. Main file processing is done on a 360/50. An on-line subset resides on DECTape on the PDP-8/I. This subset is accessed through a Teletype on the labor floor.

Initial development in on-line monitoring of high-risk obstetric patients has been accomplished with a LINC-8.¹

¹ McKeown, M. J.; Bush, R.; and Domizi, D.; A computer system for the monitoring of intensive care obstetric patients. J. Reprod. Med. 3: 275-277 (1968).

Communication to the 360/50 by the PDP-8/I is over Dataphone into a dedicated 4K partition.

FLIRT - FILE LANGUAGE IN REAL TIME

K. R. Morin, St. Paul's Hospital Laboratory, Vancouver, British Columbia, Canada

FLIRT, an intermediate-level language which directs file transactions between Teletype, core, and DECTape is being developed for the PDP-9. A FLIRT file may contain any number of records; each record contains alphanumeric elements of variable length (6-bit characters); an element can be a simple item or another record (nesting limited to 4-deep). Each file is stored in as many 64-word blocks on DECTape as necessary.

FLIRT contains about 20 verbs, e.g., ASK (ask question on Teletype and store response in core), MOVE (move item(s) from one record to another in core), WRNFL (write a new file on DECTape), and LOCREC (locate a record on DECTape which meets the specified conditions). Four verbs direct movements to/from a queue-buffer area. Record formats and most mnemonics are user-defined. The FLIRT subroutines will occupy about 5K of PDP-9 core.

A COMPUTER CONTROLLED SARCOMERE LENGTH CLAMP

Paul J. Paolini, Jr., Division of Biological Sciences,
The University of Georgia, Athens, Georgia

An experimental method has been devised to allow computer-controlled determination of the stress-strain curve which characterizes the series elastic component (SEC) of an excised vertebrate striated muscle. This information is used to derive a shortening vs. time waveform of the muscle's SEC during an isometric twitch: the calculated curve is then mechanically applied to the muscle during a twitch so that, on the average, no SEC shortening occurs and contractile component elements (the sarcomeres) remain at constant length. The muscle's tension and volume change vs. time waveforms are recorded with this condition imposed. The system employed to control and monitor contraction parameters (with length, tension, and volume transducers) consists of a 4K PDP-8 computer, a multiplexed AF01A A-to-D Converter, a set of program-controlled relays, and a Type 34D Display to provide the analog input for a servo motor which sets muscle length, as well as to interface a display oscilloscope and X-Y recorder. Program output consists of many keyboard selectable types of waveform displays, each with alphanumeric display of calibrated sensitivities and time scales.

OBTAINING A CASE HISTORY BY COMPUTER

Theodore R. Sarbin, Human Factors Laboratory, University
of California, Berkeley, California

In the course of an initial visit, an optometrist obtains a case history from the patient. This paper describes a program and allied hardware devices which are used to obtain this information directly from the patient. This Computer Generated Audio System using a PDP-8 may be used for any type of interrogation, including general patient history.

System demonstrations in Berkeley can be arranged upon request.

AN APPROACH TO MICRO-IMAGE ENCODING AND AREA SCANNING OF THE CELLS OR NUCLEOLI OF BRAIN

Dr. Hideo Seo, Biophysical Research Laboratory,
University of Illinois, Urbana, Illinois

A new system consists of the three subsystems, namely, (1) PDP338 - PDP-8, (2) optical system which overlays

visual display and photomicrographic images, and (3) photomicrograph projector.

Significant contributions in this system are in the use of a light pen with visual display as a data inputting device instead of mere functional control of the computer via interrupt mode and in the optical image superposition technique.

The boundary of a cell or nucleolus is traced with a light pen, and the area is computed immediately within three percent. Real microscopic image is also successfully processed with CCTV.

A DESIGN CRITERIA FOR DDC SYSTEM FOR ULTRASONIC IRRADIATION OF BRAIN

Dr. Hideo Seo, Biophysical Research Laboratory,
University of Illinois, Urbana, Illinois

Ultrasonic irradiation for quantitative neuroanatomy at BRL requires 0.001 inch accuracy positioning of the transducer so that carefully controlled lesion can be introduced without destroying the intervening brain tissue except at its focal point.

The above operation is done manually until the forthcoming use of automatic DDC System to prevent human errors and reduce operation time.

This paper presents the basic procedures and steps desired for optimum system design for automatic irradiation. The associated hardware for the PDP-8 interface and software programs both for the system diagnostics and for the routine operating procedures are discussed.

DESIGN PHILOSOPHY OF AN INTEGRATED LABORATORY-HOSPITAL INFORMATION SYSTEM

Garth Thomas, Systems Research Department, The Ohio
State University Hospitals, Columbus, Ohio

The integration of a Laboratory Information System being developed within the larger framework of a Hospital Information System will be presented. Using a small LINC-8 computer to perform the required functions within the clinical laboratories and divorcing its operation from any required hospital functions, provides the maximum flexibility in its utilization within the laboratory operation. Whereas, those functions which can be performed more conveniently and economically by a central computer facility can be used to maximum advantage without any major effect upon efficient operation of the laboratory. The significant consequences, advantages, and disadvantages will be discussed within the framework of the general system design philosophy employed.

INTERACTIVE SYSTEMS SESSION

GRAPHICS - TERMINAL COMMUNICATIONS PACKAGE

Barry R. Borgerson, Project Genie, University of California, Berkeley, California

The SDS-940 user program communicates with the display hardware through a communications package operating between the SDS-940 and a PDP-5 which shares memory with the display controller. By transferring and buffering all data and control words, the communications package handles the timing problems for the user.

With the aid of an unpluggable hardware addition, the PDP-5 runs under an interrupt monitor which handles all of the I/O for its end of the communications package.

The actual transmission between the two computers is done over a high-speed, half-duplex link and a low-speed, full-duplex path. All of the transfers over the half-duplex line are set up on the low-speed path.

AN EXECUTIVE FOR A REMOTE INTERACTIVE GRAPHICS TERMINAL

Claudia G. Conn* and Pamela T. Hughes, Computer Sciences Corporation, Huntsville, Alabama

This paper describes the development of an executive system for a PDP-9/339 used as a graphics terminal remotod to a triple processor UNIVAC 1108. It includes the design of a higher-level interactive programming language which is processed interpretively by the executive system. This language allows the programmer to monitor, direct, and respond to operator actions at the scope and to communicate with the central site computer without requiring any knowledge of the terminal hardware or software. This executive system handles all I/O, interrupts, allocation of free storage, tracking, and display file management.

DESIGN AND USE OF A DATABREAK DISPLAY FACILITY FOR PDP-8

E.R.F.W. Crossman, Ph.D., Department of Industrial Engineering and Operations Research, University of California, Berkeley, California

Our current research requires the use of contact-analog displays simulating the motion of a landscape as seen in perspective from a moving automobile or other vehicle. By employing geometrical approximations and table-look-up methods, it proved possible to generate only marginally adequate displays using the Type 34D display-controller. An improved display controller was,

therefore, designed using: 1. hybrid computation multiplying digital-analog converters and summing amplifiers, 2. data-compression by storing 6-bit X and 6-bit Y deflections in a single word, and 3. adoption of databreak data-transfer under control of an automatic-sequence-plotting interface.

This interface permits highly-detailed, realistic contact-analog displays to be generated on line while still allowing central-processor time for performance evaluation. Hardware and software problems will be discussed.

FAST FOURIER TRANSFORM TECHNIQUES USING A DRUM FOR MEMORY EXTENSION

Ric C. Davies, Phillips Petroleum Company, Idaho Falls, Idaho

A fast Fourier transform subroutine package which is FORTRAN compatible has been developed for a basic PDP-9 computer to transform any type of discrete data. A 128K RM09 serial drum is used to readily access and store the data during computation of the fast Fourier transform. A 339 Display unit is used to display the original data and the transformed data separately or simultaneously for comparison. A paper tape punch option supplies the user with permanent copies of portions or of all the data.

A SEISMIC DATA ANALYSIS CONSOLE

Philip L. Fleck, M.I.T. Lincoln Laboratory, Lexington, Massachusetts

A software system for a PDP-7 digital computer with a cathode ray tube display has been designed to process seismic data. The system permits quick visual inspection of digitized data and allows easy application of powerful programs which operate on the digitized data or on the results of previously used programs. Some operations which can be performed are: epicenter location, beamforming, magnitude, complexity and spectral ratio computation, filtering, autocorrelation, Fourier transformation, sonogram generation, and automatic event detection. A human operator is in the processing loop, inspecting the output at each step before applying the next. This system has greatly increased the speed and efficiency of much of our seismic data processing.

REAL-TIME COMPUTING WITHIN A TIME-SHARING SYSTEM

Peter Hurley, Digital Equipment Corporation, Maynard, Massachusetts

This paper describes the capability of the PDP-10 to perform on-line, real-time tasks concurrently with time-sharing activity. The PDP-10 is not limited to a single real-time job, nor is it limited to running

solely in a background batch mode during real-time operation. While handling several real-time jobs, such as on-line process control or data acquisition, the PDP-10 system can support a complete time-sharing service including simultaneous data processing jobs, batch jobs, and program development. Of prime importance is the consideration of the general real-time problems including high priority scheduling and real-time queues. The paper discussed the implementation of some of these real-time features and is supplemented by examples of the techniques employed at existing PDP-10 installations. The paper concludes with a description of the design goals for a multi-user, real-time system which allows the running and testing of undebugged real-time jobs without degrading the performance of other jobs.

GRAPHIC SOFTWARE SYSTEM USING A PDP-9/339 SUPPORTED BY AN RM09 DRUM

Glen C. Johnson, Atomic Energy Division, Phillips Petroleum Company, Idaho Falls, Idaho

A package of PDP-9 subroutines have been developed to facilitate the use of the 339 Display and conserve storage by creating display files on the RM09 drum. This package requires 2700₁₀ PDP-9 core locations, an RM09 drum, and a 339 Display unit. These subroutines are both MACRO-9 and FORTRAN IV compatible and create display files in vector, text, and graphplot modes with parameters. Routines to initialize the 339 and service the light pen and function box are provided. A file swapping technique, from drum to core, permits execution of large files of display commands in a small core buffer.

THE USE OF COORDINATE MEASURING MACHINES FOR THE DIRECT PRODUCTION OF N/C MACHINE TOOL TAPES

Neale F. Koenig, Information Control Systems, Inc., Ann Arbor, Michigan

Digitizer applications of Coordinate Measuring Machines (CMM's) are directed toward the production of N/C tape for machining complex two- and three-dimensional part configurations. This task is best performed in a man-computer coalition, i.e., the man directs the CMM over the part and the computer performs the mathematical computations and translation of data to the desired tape format.

In order to achieve the most cost effective (i.e., low cost, high effectivity) hardware system, a great deal of concern must be paid to the development of associated computer software. Thus, such techniques as foreground/background and priority interrupt processing must occur to effect total utilization of a small, inexpensive on-line computer interfaced to the CMM. Such a system has been developed for the production of N/C machine tapes to digitize turbine blades and is fully described in the text.

A SIMPLE NEW DISK MONITOR SYSTEM FOR THE PDP-8

Theodore R. Sarbin* and Richard A. Roth, Human Factors Laboratory, University of California, Berkeley, California

A simple disk based Real Time Monitor System is described. Some of the criteria used in designing the system are discussed as well as the command language developed. The system is based on a one half million word Datadisc and a 4K PDP-8.

INTERACTIVE DEBUGGING UNDER SIMULATION

David J. Waks, Applied Data Research, Inc., Princeton, New Jersey

Debugging programs for small computers is hindered by the lack of adequate memory, proper hardware, and peripheral equipment on the machine on which these programs are ultimately to be run. This paper proposes that comprehensive simulators for small computers be developed explicitly for interactive debugging and be run on larger computers with adequate memory, peripherals and hardware to completely check out the program written for the small computer. This technique has been used at ADR for over two years, debugging large, real-time PDP-8 programs on a PDP-7.

INTERACTIVE SYSTEMS APPLIED TO THE REDUCTION AND INTERPRETATION OF SENSOR DATA

Charlton M. Walter, Air Force Cambridge Research Laboratories, L.G. Hanscom Field, Bedford, Massachusetts

The potential and limitation of various modes of man-machine interaction, involving keyboards, light pencils and color displays will be discussed and illustrated in the context of the signal data reduction, modeling, and interpretation problem area. The requirement for manipulating large bases of sensor data imposes serious constraints on the ability of any interactive system to satisfy such incompatible requirements as flexibility of modes of interaction, speed of interaction, and ability to admit multiple users. Slides and short movie sequences will be shown to demonstrate both the advantages and drawbacks of a number of "problem-oriented" modes of interaction. The utility of various types of data display, such as classical isometric signal representation, will be contrasted with more abstract projection in N-space techniques.

PDP-9 WORKSHOP

PDP-9T TIME-SHARING: PROGRESS REPORT #3

D. M. Forsyth*, University of Vermont, Burlington, Vermont, and M. M. Taylor, Defence Research Establishment Toronto, Downsview, Ontario, Canada

The paper assumes acquaintance with "PDP-9T: Time-Sharing for the Real-Time Laboratory" (Taylor, Forsyth, and Seligman, Proceedings of the DECUS 1967 Fall Symposium). We report a significant set of alterations to the hardware specifications and progress on two separate monitor systems. The hardware changes dramatically reduce core usage and disc-swapping overhead for shared pure procedures by providing 64-word "supplementary memory blocks" within the monitor space. A supplementary memory block may be accessed only by a task which "owns" or "leases" it, but such a task accesses it as readily as the task accesses its own main working memory. Supplementary memory may be read-only or read-write, but no program material may be executed in it. It is intended for the impure parts of pure procedures executed in read-only pages of the working memory. The same hardware modification expands the possible independent entry points to Vector Service Routines from 256 to 16,384.

The time-sharing software is being done in two stages. A "minimonitor," currently being debugged, will be used to permit simple multiprogramming for real-time users and as a test bed for modules of a "main monitor" which will supersede it next year. The minimonitor supports multiprogramming only among user machines which reside totally in core and does not permit "page-turning." With the later addition of disc-swapping for entire user machines, the minimonitor system should support one or two fast-response experiments simultaneously with 3-4 conversational mode Teletype-controlled programs plus a batch-processing background operation. The Guaranteed Maximum Latency structure (Taylor, Forsyth, and Seligman, op.cit.) will not be implemented in the minimonitor but forms the basis of scheduling for the main monitor.

PDP-9 MONITOR SYSTEM WORKSHOP

David Leney and James Murphy, Digital Equipment Corporation, Maynard, Massachusetts

This lecture, discussion session, and demonstration is directed towards the presentation of major new developments in the PDP-9 ADVANCED Software System and towards the solution of existing trouble areas of general concern.

The new developments include:

1. Background/Foreground (two user time sharing) Monitor System.

2. Multi-user FOCAL system which may operate as the Foreground or Background job under control of the B/F Monitor System.

3. The 339 Software Package.

On Saturday, December 14, 1968, the PDP-9 equipped with 32K of core memory, API, EAE, Memory Protect, LT19 with four KSR-33 Teletypes and five DECTapes along with knowledgeable DEC personnel will be available the entire day for the purposes of problem solving and specific demonstrations.

OPERATING THE KEYBOARD MONITOR SYSTEM FROM A DISK

C. W. Richardson, Atomic Energy Division, Phillips Petroleum Company, Idaho Falls, Idaho

The Disk Monitor Program is designed to allow efficient use of a disk or drum by the Keyboard Monitor System. A basic PDP-9 with DECTape and any size drum or disk is sufficient to operate the monitor. DECTape is used for permanent storage. There is no need for protected or reserved areas for system programs since only those programs being used need be on the disk. System and user programs and user data sets are transferred from the DECTape to the disk for fast access by the computer. The time required for such tasks as program editing and compiling can be reduced by a factor of 10.

REVISED SUBROUTINE LIBRARY FOR EAE PDP-9

L. R. Turner*, E. C. Ilean, and Paul Manos, NASA-Lewis Research Center, Cleveland, Ohio

A new library of subroutines for floating-point arithmetic and mathematical functions has been specified and is nearly complete. As of September 5 it is undergoing tests for compatibility with the existing FORTRAN compiler. It is expected that the function library, except perhaps for exponentiation, will have been tuned up and well tested by December. The complete specifications will be briefly reviewed, and modifications for the user who wishes to use only single or only double precision operations will be discussed as will proposed (hopefully minor) modifications to the compiler and executive system.

FASBAC PDP-9 TIME SHARING OPERATING SYSTEM

V. J. Zapotocky, University Computing Company, Dallas, Texas

The U.C.C. FASBAC System provides for remote access to a general-purpose file editing capability and a string handling programming language. Input files may be UNIVAC 1108 program files or data files which are to be submitted through direct access to run on the 1108.

The time-sharing operating system has been implemented on a 32K PDP-9 with a 524K drum and a specially built controller to allow sharing of a FASTRAND mass storage device with the 1108 and direct core-to-core transfers between the PDP-9 and 1108. This paper consists of a functional description of the PDP-9 operating system and some implementation problems which should be of common interest to PDP-9 users.

PDP-8 WORKSHOP

TS-8 MAGNETIC TAPE SYSTEM

Charles R. Conkling, Jr., Infotec, Inc.,
Plainview, New York

This paper describes the Infotec, Inc., TS-8 Magnetic Tape System. This system allows the user to write and read IBM 7 Track Magnetic Tapes on the DEC PDP-8 family of computers.

It also describes the programs that will be submitted to the DECUS Program Library. These programs are as follows:

- A. Program Subroutines (IBM BCD 7 track)
 1. Read a block and store in Buffer area.
 2. Write a block from Buffer area.
 3. Tape Service (load Point, Rewind, Space).
- B. Program Routines to Load Programs from Magnetic Tape.
- C. Fundamentals of a Magnetic Tape Operating System.

ACCESSING DATA ARRAYS AND TELETYPE TEXT INPUT/OUTPUT

David G. Frutchey, Beckman Instruments, Inc.,
Fullerton, California

Two subroutine packages were developed during a project regarding the measurement of the Acid-Base Balance of Human Blood in a real-time system environment. When used with any of the standard Floating Point Packages, these subroutines provide the user with a powerful, yet concise, programming methodology. The first subroutine package entitled "Array Accessing Subroutine Package" permits the user to access both fixed and floating point data located anywhere in the first 2K (K=1024) words of core storage regardless of page overlap. Both data storage and retrieval can be performed on terms analogous to singly-subscripted FORTRAN array terms such as "ARRAY(a*J±b)." The second subroutine package, entitled "TTY TEXT I/O," provides a concise facility for text output (63 characters), character input, line spacing and page tabs. Application programming examples are included.

OS/8: OPERATING SYSTEM FOR PDP-8

Russell B. Ham, U.S. Public Health Service,
Winchester, Massachusetts

OS/8 is a DECTape-based operating system for the PDP-8 which includes a set of file management programs, loaders for absolute binary (PAL output and core-image saves) and relocatable binary (8K FORTRAN and SABR output), an editor (Symbolic Editor for 4K or TECO-8 for 8K), and an assembler (PAL-IV for 8K).

This discussion will deal with the file management programs which have the following properties:

1. System tape may be write-locked; all unit numbers may be utilized for reading or writing files.
2. Files need not occupy consecutive blocks on tape, and deleting a file does not disturb other files.
3. System I/O uses program interrupt.
4. Six character file names plus one character file type identifiers may be reused without losing the earlier files.
5. File directories may be listed selectively; system files are not listed.

TECO-8: TEXT EDITOR AND CORRECTOR PROGRAM FOR THE PDP-8

Russell B. Ham, U.S. Public Health Service,
Winchester, Massachusetts

TECO is a sophisticated editor program which operates on character strings rather than lines of text. This version is derived from the specifications for PDP-10 TECO with the following additions:

1. Separate line-oriented and character-oriented commands.
2. A Replace command.
3. Commands to load a Q-register or produce output directly.
4. Extensive formatting of console Teleprinter output.
5. Ability to specify sets of strings in a Search command.
6. Provision for lower-case USASCII characters.

TECO-8 requires 8K or core and EAE; high speed reader and punch are very desirable. DECTape I/O under OS/8 (q.v.) is available from the author. All I/O is buffered and uses program interrupt. Ten Q-registers (auxiliary text buffers or command macros) are provided.

A DISC ORIENTED REAL-TIME EXECUTIVE FOR THE PDP-8/S COMPUTER

W. T. Lyon, Aluminum Company of America, Pittsburgh, Pennsylvania

This Executive was written to operate in a real-time environment for process control.

The original version of the program provides 12 levels of priority. It allows for up to 115 separate programs allocated to various priority levels. It decodes 24 process interrupts and provides 24 software timers.

In addition, the system has a keyboard monitor to perform such utility functions as binary punch and octal dumps of core or disc. Restructuring of the system can be accomplished by reassembly.

AUTOMATIC SUBROUTINE LINKAGE ACROSS CORE BANKS IN A PDP-8

Joseph Rodnite, Information Control Systems, San Francisco, California

The problems associated with automatic subroutine linkage between core banks are manifold. The basic problem is that the machine word has 12 bits available for an address and the addresses are greater than 12 bits. The algorithm presented is used in the implementation of the 8K FORTRAN compiler. The problem is approached from an assembly language level and extends through the loader and resident operating system. An understanding of the memory extension hardware is necessary to fully understand the algorithm presented.

TMF - A PROCEDURAL SOFTWARE PACKAGE FOR BIOMEDICAL AND SCIENTIFIC APPLICATIONS ON THE PDP-8

Fred R. Sias, Jr.*, and Allan B. Wilson, University of Mississippi Medical Center, Jackson, Mississippi

Programmers using high-level compilers such as FORTRAN find the procedural capabilities of the language at least as useful as the arithmetical features. While floating point arithmetic software packages are usually provided by computer manufacturers to ease the programming effort when using assembly languages, analogous procedural packages are usually not available.

TMF is a procedural software package including an Input-Output Control System (IOCS-8) for use with the PAL III or MACRO-8 assembly systems on the PDP-8 series of machines. A number of definitions are added to the permanent symbol table of each assembler to permit execution of procedural subroutines analogous to FORTRAN statements such as IF, GOTO, DO, READ, WRITE, CALL, and RETURN. A keyboard monitor and relocating loader is included in the basic system.

Neurophysiological and statistical examples of application will be shown that are more compact and faster than analogous programs written in PDP-8 FORTRAN.

TSS/8: GENERAL PURPOSE TIME-SHARED PDP-8

Don Witcraft, Digital Equipment Corporation, Maynard, Massachusetts

This will be a presentation of the TSS/8 including:

1. philosophy of design,
2. philosophy of implementation,
3. operational characteristics, and
4. library programs included under TSS/8.

A question period and demonstration will follow.

PDP-6/10 WORKSHOP

SYNCHRONOUS COMMUNICATION INTERFACE FOR THE PDP-10

Norman Housley, The University of Western Ontario, London, Ontario, Canada

Most remote card reader/printer terminals (whether computer or wired logic controlled) commercially available utilize the synchronous communication method of data transmission. The PDP-10 hardware/software presently does not support such devices. The University computing center is committed to providing remote job entry facilities using card reader/printer terminals. Data rates of up to 2400 bits per second (using the 201B data set) are contemplated.

A solution to this requirement is the use of additional Teletype receiver/transmitter modules (DEC W-706/707) as a front end to the PDP-10 data line scanner. The present scheme uses two receivers and two transmitters in addition to one scanner channel. This system gives almost a full character time for the software to service the synchronous line as opposed to the existing system which allows approximately 1 1/2 bit times for servicing.

RAPID PROGRAM GENERATION USING THE DEC PDP-6/10 TIME-SHARING MONITOR

William F. Weiher, Stanford Artificial Intelligence Laboratory, and Richard P. Gruen, Digital Equipment Corporation, Palo Alto, California

Rapid Program Generation on the PDP-6/10 has been made possible by the addition of five commands to the

DEC Time-Sharing Monitor. These commands (EXECUTE, DEBUG, COMPILE, LOAD, and CREF) allow the time-sharing user to specify the names of the programs which he wishes to use and then delegate to the Rapid Program Generation System the task of compiling, assembling, and loading these programs, as needed, without requiring the user to type CUSP commands. The implementation makes use of an RPG cusp and some small files on the disk; only nine additional instructions have been added to the Time-Sharing Monitor.

MODULES/HARDWARE WORKSHOP

PROGRAMMED MIXED MODE DATA COMMUNICATION

Hans J. Breme, Western Electric Company, Princeton, New Jersey

An arrangement for data acquisition by a PDP-8 from remote terminals such as IBM 2701, 7702, 1013, 7711 including the "synchronous Transmit Receive" mode is shown. The problem of maintaining bit phase with the starting record is overcome by modifying the DEC DPOIA interface. The synchronization with varying characters is programmed and uses the OR-buffer. Error detection and correction is accomplished via software either in the ARQ or FEC mode. The PDP-8 may communicate with several remote terminals simultaneously, they need not be the same type.

PDP-8/S IBM 360/65 DATA LINK

Larry Green, Department of Psychology, University of California, Santa Barbara, California

A PDP-8/S is dedicated to collection of psychophysical and behavioral data from several laboratories for transmission to an IBM 360/65. When massive computation is required, paper tape data or converted analog data is loaded into the 8/S where a preprocessing routine determines if the data merits analysis. If the data is valid, it is block-transferred into the 360/65 for manipulation and display of terminal data through the Culler-Fried Teleputer System.

System organization, interfacing hardware, and difficulties encountered during development will be described.

RECENT EXPERIENCES IN DESIGNING MODULAR INTERFACES USING M-SERIES LOGIC

Gary B. Morgan, Idaho Nuclear Corporation, Idaho Falls, Idaho

The use of M-series (T²L integrated circuit logic) modules for interfacing to computers which are constructed using B and R series modules involves some

new considerations. This paper will deal with three major areas of concern: the economics of using M-series vs. standard R-series, system design of I/O using T²L logic for interfacing on-line control and data acquisition experiments, and specific problems and solutions when using the M-series line for an interface. (Including special cards which have been designed.) A specific data acquisition and control interface for a PDP-9 will be used as an example of the three general areas above.

A DATA COMMUNICATION SYSTEM FOR THE PDP-8 IN ARBUS

Thomas G. Taussig, Lawrence Radiation Laboratory, University of California, Berkeley, California

A data communication interface developed for ARBUS (Advanced Reservation and Bed Utilization System—paper to be presented by R. Abbott, Biomedical Session) will be described. The low cost, high speed data break interface allows the connection of multiple duplex Tele-type stations and data phones to the PDP-8. The design of this system results in low program overhead requiring less than 5 percent of computation time to assemble characters from 32 lines, sampling at 8 times the 110 baud rate. The system requires 2 words of memory per line.

FOCAL WORKSHOP

Rick Merrill, Digital Equipment Corporation, Maynard, Massachusetts

The data structure of FOCAL, the use of certain subroutines, and the creation of new functions will be examined. Discussion will elaborate upon the LIBRARY command, its uses, forms, and implementation with the intention of finalizing the design of Disk FOCAL.

LOCAL USERS GROUP MEETING

At Stanford University, a Stanford Local DECUS Users Group (SLUG) has been organized for the purpose of pooling DECUS software information in a local area and bringing about a closer working relationship between the users of 35 or so various PDP-1's through PDP-10's on campus. Some of their initial objectives are: to present to DEC, in a uniform manner, opinions (good, bad, or indifferent) regarding DEC software; and to create a central local source for information exchange on software and hardware problems, as well as latest changes in software and manuals.

The University of California, Berkeley Campus and Lawrence Radiation Laboratory at Berkeley and Livermore have also formed such a group for the same purposes. During this meeting, they will present what has been done and discuss the value of LUG's.