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PDP-8 I/O AND INTERRUPT PROGRAMMING SYSTEM FOR SPARK CHAMBER DATA LOGGING PROGRAMS

Introduction

A special system has been provided for the PDP-8 tailored to the specific I/O and interrupt handling needs in utilizing the computer for on-line data logging and monitoring functions of a spark chamber experiment. Hopefully the system will realize the following goals:

1. Simplify the use of input/output operations and interrupts in the users' programming for specific experiments.
2. Provide a fixed overall philosophy for data logging and monitoring while at the same time leaving sufficient flexibility to enable the user programs to determine what is to be done.
3. Provide a programming mechanism such that given sufficient memory the user can match his event input rates and tape record output rates.
4. Provide the basic I/O drivers, data conversion, and utility routines that are likely to be needed for programming by different users.

If these goals are sufficiently met, the effort required to produce user programs should be significantly reduced.

General Philosophy

The general philosophy of the I/O and interrupt system is influenced by the following features of the total spark chamber system:

1. The interrupt system off-mode of the computer is sensed and used by the spark chamber central control to determine if triggering the spark chamber should be inhibited.
2. The peak rate at which events can occur is once every 400 ms due to other components of the spark chamber system.
3. Data is written on the incremental tape unit at a maximum rate of one character each 3.5 ms, and each record gap requires approximately 500 ms.

The system requires the user programs to fall into one of four categories:

1. Initialization - this type of program sets the initial conditions and establishes linkage to the system prior to the start of each run. It is assumed that triggering of the spark chamber should be inhibited during the execution of this program, hence the system gives control to this type of program with the interrupt system off.
2. Event Processing - this type of user program processes the raw data placed in core memory due to the occurrence of an event. It is assumed that as a result of this processing only one record of data will be written; therefore, when control is given to this program space for only one record is guaranteed available to the user. It is assumed that in most cases this processing takes on the order of 20 - 30 ms. Due to the relatively slow event input rate, the integrity of the system does not suffer if this processing is performed with the interrupt system off. Whenever an event interrupt occurs control is given to this type program with the interrupt system off.
3. Background - this type of user program performs some background function whenever the computer is waiting for an interrupt to occur. The most common use would be to display data, such as a histogram, on the CRT. This program should be a non-terminating one and control will always be returned to it after interrupts have been processed.
4. Special Processing - this type of program is initiated by a control character on the teletype. It is assumed that during the execution of this type of routine, triggering of the spark chamber is not desired and therefore control is transferred to programs of this type with the interrupt system off.

The system provides routines to facilitate the usage of the teletype, incremental tape, and the CRT.

The teletype driver provided allows the user to specify either a one or two character per word data mode with or without a carriage return/line feed at the completion of the teletype I/O request. Due to the special use made of the interrupt system on/off status, the teletype driver is not interrupt driven, but is executed on a wait basis. Caution must be exercised in calling the driver from a background program and should be avoided if possible.

Control of the incremental tape is the responsibility of the system. The user has the responsibility to form the data records using the routines and procedure provided by the system, but the occurrence of the actual output of the record and the blocking of records is accomplished by the system. The output records are queued to match average input and output rates. The system blocks 20 fixed length records into one physical record. A routine, DEFINQ, is provided to facilitate the user initialization program to define the number and locations of the output buffers to be queued. After this initial specification the user need not be concerned with the buffer location except to assure that the memory assigned as buffers is not used for any other activity. Whenever the event processing program is entered, the system has guaranteed the availability of at least one buffer. All active buffers are output by the system prior to transferring control to any of the special processing programs. The tape driver used by the system is interrupt driven unless all buffers are full so that in most instances the event input rate is not affected by output activity on the tape.

A somewhat simplified approach has been taken in the utilization of the CRT. A routine, DSHIST, is provided to facilitate painting line histograms using a linear scale. No additional capability has been provided.

Programming Information

This section is provided to describe the requirements of the system that must be satisfied by the user and to describe the routines available to assist user programming.

All user programs, except the background, are entered with a subroutine jump. The user must allow for the proper entry when programming.

The entry point to the user initialization program should be assembled into location 0007. During execution of the user initialization the following pointers should be set:

USERDI - Defines entry point for event processing program

USERBG - Defines entry point for background program

USERCT - Defines transfer point for a restart when re-initialization is not desired.

The initialization program must define the number of output buffers and the starting location less one of each buffer. The system routine, DEFINQ, is provided for this purpose. The number of special processing programs, the control

character that initiates each one, and the entry point of each must also be specified. The system routine SUKBCC should be used for this specification. The system uses a 100 character fixed length record to contain each logical record formed by the user. The first two characters of each record contain the size of the logical record, hence the maximum logical record is 98 characters. During initialization the user may change the record size to a value between 3 and 100 by placing the two's compliment value of the record size in RECLTH. If it is desired to change the system blocking factor from 20, the two's compliment value of the new factor must be placed in RECCT and BLKSZ during initialization. The total number of records that can be formed during initialization is equal to the number of output buffers provided by the user. When the initialization program is completed, control must be returned to the system through the initialization entry point.

Upon entry to the event processing program the data associated with the current event is in locations 7700_8 - 7777_8 in a format determined by the experiment. The only requirements of the system are that only one record be formed and that control be returned to the system through the entry point when processing is completed.

As with entry to the event processing program, entry into any special processing program inhibits spark chamber triggering. Before the system transfers control to a special processing program all active output buffers are output, therefore a special processing program may form as many records as there are buffers. Upon completion control must be returned to the system through the entry point.

The user may use low core locations 100_8 - 172_8 and auto-index locations IR1 - IR5. IR2 - IR4 are never used by the system.

A set of routines is provided in the system which must be used to form an output record. To form a record the user must first call the routine OPENRC. The record is actually formed by using the following routines as often as necessary:

ENASCU - Enter ASCII/one character per word

ENASCP - Enter ASCII/two characters per word

ENBCDE - Enter BCD/one character per word

ENBCDP - Enter BCD/two characters per word

ENBINI - Enter 12 bit binary

All source data is converted to BCD if necessary by these routines, and the record is formed with two characters per word to conserve space. When all data is entered in the record, the user terminates the record formation by calling the routine CLOSRC. If the user attempts to overflow the output buffer or to call OPENRC again before calling CLOSRC, a transfer is taken to the location specified by the last legitimate OPENRC call. If the value of the accumulator is zero an overflow occurred.

Teletype Input Routine

This routine has four entry points which all use the following calling sequence:

```
                    (number of character to be input in AC)
P       JMS         (entry name)
P + 1               (buffer location - 1)
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Control is always returned to P + 2. The routine recognizes and takes the described action for the following characters:

left arrow - erase last character

rubout - erase entire line

carriage return- terminate input and substitute 77_8 for C/R.

Upon return to the calling program the accumulator contains the count of the characters input. The contents of IR1 are destroyed by this routine. The characters read are placed in the buffer location in a one or two character format as specified by the entry. A carriage return and line feed is given on character count termination if indicated by the entry. The entry points are as follows:

RD1ASC - one character/word with C/R

RD1ASN - one character/word without C/R

RD2ASC - two characters/word with C/R

RD2ASN - two characters/word without C/R

Teletype Output Routine

This routine has four entry points which use the same calling sequence form as the input routines. The entry points define the format of the data as full (one character per word) or truncated (two characters per word) ASCII, and specify if a carriage return is to be given or not at the completion of the operation. The operation is normally terminated by satisfying the character count specified in the accumulator upon entry to the routine. The other method of termination is initiated by a 77_8 character appended to the end of the output

character string. The user must not specify a character count larger than the line length of the teletype. If he does, characters will be overprinted in the last character position of the line. The entry points provided are:

W1ASCR - one character/word with carriage return

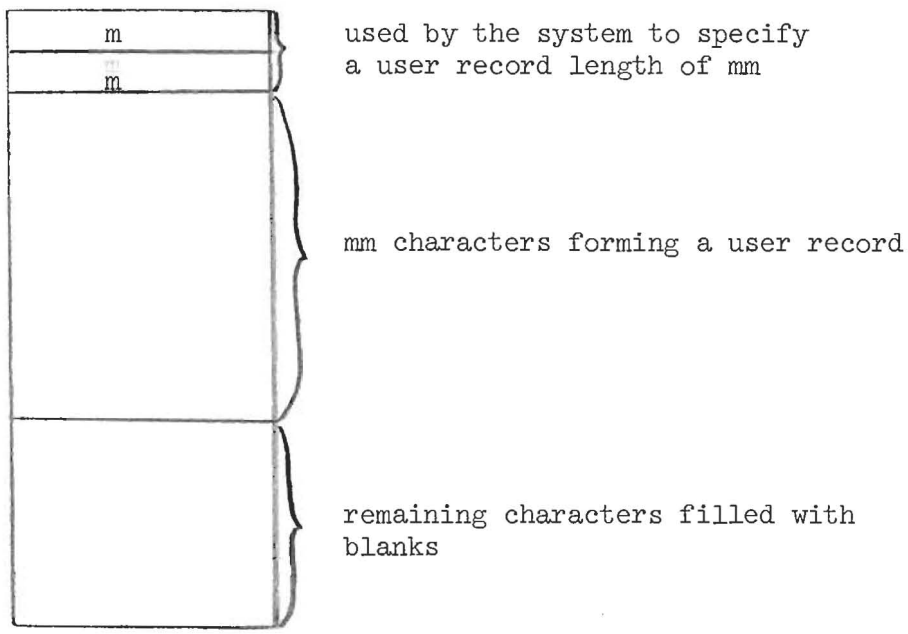
W1ASCN - one character/word without carriage return

W2ASCR - two characters/word with carriage return

W2ASCN - two characters/word without carriage return

Record Formation Routines

The following routines are provided the user to form each record. Through the use of these routines buffer space is determined which will hold the record image, the system is notified when a record is available to be output, and data conversion and formatting for the record image is performed. The record image is in external BCD - two characters per word. The overall record format is as follows:



System logical record (100 characters)

A physical record on tape consists of 20 system logical records.

Open Record Routine

This routine has the following calling sequence:

P	JMS OPENRC
P + 1	(location of error exit)
P + 2	(normal return)

This routine must be called at the beginning of each record formation. This notifies the system to determine the location of the buffer to be used

by the formatting routines and specifies the location to which control is to be given if an error occurs during record formation. This routine must always be paired with a call to CLOSRC. If OPENRC is called again before CLOSRC, an exit is taken to the error exit specified by the first OPENRC call.

Close Record Routine

This routine has the following calling sequence:

P	JMS CLOSRC
P + 1	(normal return)

This routine must always be called to indicate the completion of record formation. The call causes the system to place the character count in the first two character positions of the system logical record, to blank any remaining character positions in the system logical record, and to indicate that the record is ready for the system to write the record on the incremental tape.

Data Conversion and Formatting Routines

Three routines are provided to transfer data provided by the user to the record buffer area. All routines use the following calling sequence:

	(character count in AC)
P	JMS (routine entry name)
P + 1	(location of source buffer less one)
P + 2	(normal return)

The routines use IR6 to point to the source buffer position and IR7 to point to the target buffer position. IR7 is initially set up in OPENRC. If an overflow condition of the target buffer occurs during any of these routines, control is transferred to the error exit specified by the OPENRC call. This transfer is made with a direct jump and the contents of the AC is zero to indicate the overflow condition. The routines provided are:

1. Enter ASCII source data. This routine has two entry points which specify either full 8-bit ASCII (one character per word) or truncated (two characters per word) ASCII source data. The ASCII code is converted to the BCD equivalent for:
    a. All alphanumeric characters
    b. Special characters:
        1. Plus sign
        2. Minus sign
        3. Asterisk
        4. Slash
        5. Period

6. Comma
7. Left parenthesis
8. Right parenthesis
9. Equal sign
10. Dollar sign

All other ASCII characters are converted to a blank. The entry point names are:

a. ENASCU - Enter ASCII unpacked (one character per word)
b. ENASCP - Enter ASCII packed (two characters per word)

2. Enter BCD source data. This routine has two entry points which specify either one or two BCD characters per word source data. Since no conversion is required, the routine only packs the characters in the target buffer. No check is performed for legal BCD characters. The entry point names are:

   a. ENBCDE - Enter BCD unpacked (one character per word right justified)
   b. ENBCDP - Enter BCD packed (two characters per word)

3. Enter Binary Integer data. The entry point name for this routine is ENBINI. This routine converts a binary 12-bit two's compliment value to the absolute value in BCD and stores it in the target buffer. Since the range of the converted value is 0 through 2047, four character positions are required for a maximum value. If upon entry the number of characters specified in the AC is greater than 4, the leading character positions are filled with blanks. However, if less than four characters are specified the least significant digits are used.

Display Histogram Routine

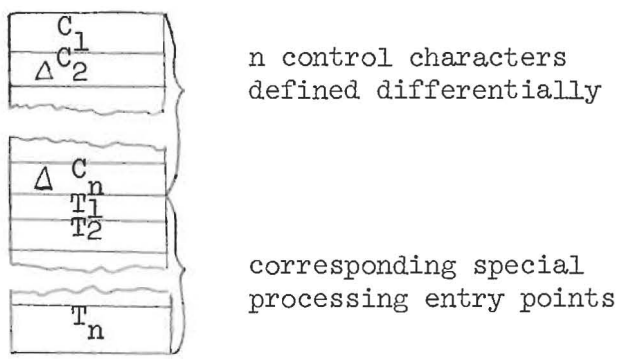
This routine is provided to simplify the programming effort required to display line histograms. It allows the user to specify the number of values to be histogrammed, the location of the table of values, the starting horizontal (x) position of the display, and the separation between individual lines. Each call causes the display to be traced once on the CRT, hence the routine must be called repeatedly to maintain the display. Several tables of values may be displayed simultaneously by using separate, successive calls for each table of values and the display may be maintained by repeating the group of calls continually. The routine will display a value range of 0 through 1023. Any positive value greater than 1023 is changed to 1023 and negative values

are changed to an absolute value. The calling sequence for this routine is as follows:

	(number of values in AC)
P	JMS DSHIST
P + 1	(horizontal positioning value)
P + 2	(separation value)
P + 3	(location of values table less one)
P + 4	(normal return)

Setup Keyboard Control Characters Routine

This routine must be called during the user initialization program to setup the control transfer linkage for the special processing routines. The user defines the number of control characters to be defined, and a table containing the control characters defined differentially and the transfer location specified for each. To define the control characters differentially means to order to 8-bit ASCII equivalent of the control characters in an increasing order and leaving the first character in ASCII but replacing the remaining values with the numeric difference from the previous value. As an example assume control character A and F. The values are 301_8 and 306_8 respectively and the differential definition would be 301_8 and 5. The format of the complete table for n control characters, C_1, C_2, ---, C_n and corresponding special processing entry points T_1, T_2, --- T_n would be as follows:



Control Character Definition Table

The calling sequence for this routine is:

	(number of control characters in AC)
P	JMS SUKBCC
P + 1	(location of control character definition table less one)
P + 2	(normal return)

Define Queue Routine

This routine must be called during user initialization to define the number and the locations of the output buffers provided by the user for the system. Each buffer provided must be large enough to contain a system logical record. Unless the record length is changed by the user this is a 50 word buffer. The user must provide a buffer location table that has an entry for each buffer provided. An entry in this table consists of the buffer location less one. The calling sequence for this routine is:

	(number of output buffers in AC)
P	JMS DEFINQ
P + 1	(location of buffer location table)
P + 2	(normal return)

Utility Routines

The following routines are available and may be utilized by the user.

1. Inclusive OR - performs the inclusive OR between A and B. Upon entry the value of A is in AC and the location of B is defined in the calling sequence. At exit the result is in the accumulator. The calling sequence is:

	(Value of A in AC)
P	JMS IOR
P + 1	(location of B)
P + 2	(normal return)

2. Exclusive OR - performs the exclusive OR between A and B. Substituting the entry name XOR for IOR the comments on the inclusive OR routine apply to this one as well.
3. End tape routine - this routine is provided to fill out the last block on the magnet tape with blanks to assure compatability when reading this tape on the 360/75. It should only be used just before a tape rewind. The calling sequence is:

P	JMS ENDTAP
P + 1	(normal return)

User Program Assembly

All user programs must not use the first 100_8 locations of memory or locations 200_8 through 2577_8. These are reserved for the system. Reference to any location in the system area is done symbolically. These allowed references are defined on a user symbol table. This user symbol table must always

be read in at the beginning of pass one for any user program assembly. He may then proceed normally for the remainder of the assembly.

Execution of Control Program

The system is loaded using the binary loader. If any corrections exist for the system they should be loaded next, followed by any user programs and correction tapes. After loading has been completed, the address 2000_8 should be loaded in the instruction address register. Before depressing start, one of three modes is selected with the storage access keys.

Value of Storage Keys	Meaning
0	Initial start
< 0	Continue with interrupts on
> 0	Continue with interrupts off

Immediately after loading, the initial start mode must always be selected. During execution certain errors may occur which will cause the computer to halt. These halts are:

Location of Halt	Cause
220_8	Output buffer management confused
410_8	Output buffer not available at time of OPENRC call
642_8	Number of output buffers defined as zero

Any additional halts should occur only in user programs.