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Multichannel Pulse-Height Analyzer

by

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SUBROUTINES CALLABLE FROM PDP-11 BASIC FOR CONTROL OF A
MULTICHANNEL PULSE-HEIGHT ANALYZER

by

Larry V. East

ABSTRACT

A set of subroutines written to control a multi-channel pulse-height analyzer interfaced to a PDP-11 minicomputer is described. These subroutines allow programs written in BASIC to perform all control and data transfer functions required to accumulate and analyze pulse-height spectra.

MASTER

I. INTRODUCTION

This report describes a set of subroutines that allow programs written in the BASIC language to perform data transfer and control functions on a multichannel pulse-height analyzer interfaced to a PDP-11 minicomputer.¹ The pulse-height analyzer (PHA) is a Canberra Industries (Geoscience) Model 8700 with its own 4096-word memory. An interface² between the PHA and computer allows the computer to control the analyzer functions (START, STOP, DISPLAY, etc.), test the status of the analyzer, and perform bidirectional data transfers between the analyzer and the computer. The "CALL" statement available in the most recent version³ of BASIC for the PDP-11 is used to reference the subroutines that perform PHA control and data transfer functions. Two additional routines that control and read a programmable real-time clock⁴ in the computer are included in the subroutine package.

Use of the BASIC language allows users of the computer/PHA system to easily write and debug

their own programs for on-line data acquisition and analysis. The language is easily learned and yet is powerful enough to easily handle the calculational operations required for pulse-height analysis.

II. SUBROUTINE DESCRIPTIONS

The subroutines available are summarized in Table I. These routines are referenced by "CALL" statements of the form

CALL <string expression> (argument list)
where <string expression> specifies the name of the subroutine (limited to four characters), and the argument list contains the input and output arguments required by the subroutine being referenced. The string expression is usually in the form of a literal string enclosed in quotes, but may also be a string variable.* The statement

CALL "PHAC"(Z)
is an example of the use of a literal string;

* The subroutines described in this report are not intended for use with non-string versions of BASIC-11.

TABLE 1
SUMMARY OF AVAILABLE SUBROUTINES

Name and Arguments	Action
"MCAR"(I, X)	Place value from PHA channel I into X, where $0 \leq I \leq 4095$.
"MCAW"(I, X)	Place value of X into PHA channel I, $0 \leq I \leq 4095$.
"ZERO"(I1, I2)	Zero PHA memory from channel I1 thru channel I2.
"SUM"(I1, I2, S)	Sum PHA memory contents from channel I1 thru I2 and store result in S.
"PHAC"(X)	Put PHA into operating mode determined by value of argument, which may be numeric or a string.
"PHAS"(X)	Set value of the argument to reflect the PHA operating mode. Argument may be numeric or a string.
"BAND"(I1, I2)	Set I1 to lower PHA BAND thumb switch setting, I2 to upper BAND thumb switch setting.
"CLT"	Reset live/true timer in PHA (no arguments).
"WAIT"	Wait for PHA to go to STOP (no arguments).
"CLK"(X)	Initialize or disable real-time clock in computer, depending on value of X.
"CLK"(X)	Set X equal to time in seconds since clock last initialized.

LET X\$="MCAR"

.

CALL X\$(N, Z)

is an example of the use of a string variable.

If the CALL statement does not have the proper syntax, i.e. missing quotation mark, parenthesis, comma, etc., the error message

SYNTAX ERROR AT LINE XXXX

will be issued, where "XXXX" is the line number in the BASIC program producing the error. If an argument is of the wrong type (string rather than numeric, for example), or not within the defined range, the error message

ARGUMENT ERROR AT LINE XXXX

will be issued. Any attempt to address the PHA memory by the routines in Table I when the PHA "COMPUTER" switch is in the "DISABLE" position will cause the PHA to go to STOP mode and result in the error message*

ADDR ERR AT LINE XXXX.

The following paragraphs describe in detail the subroutines, their arguments, and any additional error messages.

A. "MCAR"(I, X)

When this routine is called, the second argument, X, will be set equal to the contents of the PHA channel specified by the first argument, I. Both arguments must be numeric. The first argument must be within the range $0 \leq \text{INT}(I) \leq 4095$, and noninteger values will be truncated. Obviously, the second argument cannot be an expression or a constant.

B. "MCAW"(I, X)

The PHA memory channel specified by the first argument will be set equal to the integer part of the second argument. Both arguments must be numeric (constant, variable, or expression). Acceptable values are $0 \leq \text{INT}(I) \leq 4095$, $0 \leq \text{INT}(X) \leq (2^{20} - 1)$.

C. "ZERO"(I1, I2)

The contents of the PHA memory will be set equal to zero starting with the channel specified by the first argument thru the channel specified by the second argument. Both arguments must be numeric and in the range $0 \leq \text{INT}(I) \leq 4095$, and $I1 \leq I2$.

D. "SUM"(I1, I2, S)

The contents of the PHA memory starting at channel I1 and ending at channel I2 will be summed and the result stored in S. The contents of the PHA memory will not be altered. All three arguments must be numeric, and the third argument cannot be an expression or constant. The

* This error message may also be issued if an attempt is made to address a nonexistent computer memory location or I/O device register.

first two arguments must be $0 \leq \text{INT}(I) \leq 4095$, with $I1 \leq I2$.

E. "PHAC"(X) or "PHAC"(X\$)

This routine will put the PHA into the operating mode specified by the argument, provided that the analyzer is computer enabled. If the PHA is not computer enabled, the PHA will be placed in STOP and the error message

PHA SETUP ERR AT LINE XXXX will be issued. The argument may be either a numeric or string variable or expression. If it is a string, only the first three characters are significant. Acceptable argument values and resulting PHA modes are as follows:

X = 0, or X\$ = "STO..."; STOP mode.

X = 2, or X\$ = "DIS..."; DISPLAY mode.

X = 3, or X\$ = "COL..."; COLLECT mode.

Any other argument value will result in the "ARGUMENT ERROR" message.

F. "PHAS"(X) or "PHAS"(X\$)

The argument, which may be either a numeric or string variable, will be set to reflect the current PHA operating mode. The possible returned values of the argument are:

X = 0, or X\$ = "STOP" if PHA in STOP mode.

X = 1, or X\$ = "I/O " if PHA in I/O mode.

X = 2, or X\$ = "DISP" if PHA in DISPLAY mode.

X = 3, or X\$ = "COLL" if PHA in COLLECT mode.

G. "BAND"(I1, I2)

The arguments, I1 and I2, which must be numeric variables, will be set equal to the values set in the lower and upper BAND thumb switches located on the PHA processor panel. If the lower BAND thumb switch setting is greater than 4095, or greater than the upper BAND thumb switch setting, the error message

PHA SETUP ERR AT LINE XXXX will be issued. If the upper BAND switch setting is greater than 4095, the second argument will be set equal to 4095.

H. "CLT"

This routine resets the live/true time clock in the PHA. No argument is required or expected.

Note that the PHA clock cannot be reset by the "ZERO" routine.

I. "WAIT"

Calling this routine will interrupt the BASIC program until the PHA transfers to the STOP mode, either by manual intervention or by an automatic time-out during data collection. If the PHA is already in STOP when this routine is called, the BASIC program will immediately resume execution. Any "background" program that has been loaded with the RT-11 operating system version of BASIC will be executed while this routine is waiting for the PHA to stop. The reader is referred to Chapter 8 of the RT-11 BASIC manual³ for details on the use of a background program.

J. "ICLK"(X)

This routine will initialize (reset to zero) the real-time clock in the computer if the argument is ≥ 0 , and will disable the clock⁴ without resetting it if the argument is less than zero. Note that this routine has no effect on the PHA clock. The real-time clock must be initialized any time the computer has been halted and then restarted (either manually or by the power-fail/restart sequence), and any time that BASIC has been reentered from MONITOR.

K. "CLK"(X)

This routine sets the argument, which must be a numeric variable, equal to the time in seconds (to the nearest 0.1 s) since the real-time clock in the computer was last initialized. The clock will overflow after approximately 466 h.

III. PROGRAMMING EXAMPLES

Two short BASIC programs are presented below to illustrate the use of the PHA subroutine package. The first program puts the PHA through a data acquisition sequence and then performs a simple data analysis by summing the data over a group of channels selected by the BAND switches. Note that the single line

180 CALL "WAIT" could have been used in place of lines 180 and 190.

SAMPG1 01-OCT-74 BASIC V01-05

```

10 REM SAMPLE BASIC PROGRAM USING PHA SUBROUTINE PACKAGE
100 LET R$="GO"
110 PRINT "ENTER REGION OF INTEREST ON BAND SWITCHES"
115 PRINT "TYPE "GO" WHEN READY"
120 INPUT X$
125 IF X$=R$GOTO 115
130 CALL "BAND"(C1,C2)\REM - GET REGION OF INTEREST
140 CALL "CLT"\REM - CLEAR PHA LIVE TIME CLOCK
150 CALL "ZERO"(0.4095)\REM - CLEAR PHA MEMORY
160 CALL "PHAC"("COLLECT")
170 CALL "CLK"(1)\REM - INITIALIZE REAL TIME CLOCK
180 CALL "PHAS"(X)
190 IF X=0GOTO 180 \REM - WAIT FOR PHA TO STOP
200 CALL "CLK"(T)\REM - GET REAL TIME
210 CALL "PHAC"(2)\REM - PUT PHA INTO DISPLAY
220 PRINT "FINISHED -- REAL TIME = "T;" SECONDS."
230 CALL "SUM"(C1,C2,Z)\REM - SUM REGION OF INTEREST
240 PRINT "SUM FROM CHANNEL "C1;" TO "C2;" IS "Z
250 CALL "PHAS"(X)\REM - GET PRESENT PHA STATUS
260 PRINT "PHA IS NOW IN "X;" MODE."
270 LET R$="YES"
275 PRINT "DO IT AGAIN ?"
280 INPUT X$
290 IF X$=R$GOTO 100
300 STOP

```

READY

RUN

```

ENTER REGION OF INTEREST ON BAND SWITCHES
TYPE GO WHEN READY
700
FINISHED -- REAL TIME = 11.7 SECONDS.
SUM FROM CHANNEL 361 TO 380 IS 49678
PHA IS NOW IN DISP MODE.
DO IT AGAIN ?
700

```

STOP AT LINE 300

READY

Program #1

The second program illustrates the use of "MCAR" and "MCAW" for data transfers between the PHA and computer. In this program, data from the PHA are read into a "virtual array" data file (a random access tape or disk file available with the RT-11 operating system version of BASIC-11) and then read back into the PHA from the file.

SAMPG2 01-OCT-74 BASIC V01-05

```

10 REM BASIC PROGRAM TO WRITE PHA CONTENTS INTO A "VIRTUAL ARRAY"
15 REM DATA FILE AND THEN READ THE VIRTUAL ARRAY BACK
20 REM INTO THE PHA MEMORY.
100 PRINT "TYPE FILE NAME"
110 INPUT R$
120 OPEN R$ FOR OUTPUT AS FILE VF1(4095)
130 PRINT "FILE WILL BE WRITTEN WHEN PHA STOPS"
140 CALL "WAIT"
200 FOR I=0 TO 4095
210 CALL "MCAR"(I,X)
220 LET VF1(I)=X
230 NEXT I
300 REM NOW CLEAR PHA MEMORY AND READ DATA BACK FROM VF1
310 CALL "ZERO"(0.4095)
320 FOR I=0 TO 4095
330 CALL "MCAW"(I,VF1(I))
340 NEXT I
350 CALL "PHAC"("DISP")
370 CLOSE VF1
400 STOP

```

READY

RUN

```

TYPE FILE NAME
700:TEST
FILE WILL BE WRITTEN WHEN PHA STOPS

```

STOP AT LINE 400

READY

Program #2

REFERENCES

1. Manufactured by the Digital Equipment Corporation, Maynard, Massachusetts.
2. Manufactured by Canberra Industries, Meriden, Connecticut.
3. "BASIC/RT11 Language Reference Manual," Digital Equipment Corporation Manual DEC-11-LBACA-B-D (1973).
4. Obtained from Tennecomp Systems, Inc., Oak Ridge, Tennessee. The clock routines could easily be modified for use with a standard PDP-11 programmable clock.