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AIR FORCE HUMAN RESOURCES LABORATORY

SOFTWARE FOR PERFORMANCE TRAINING CARREL

By

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MARTY R. ROCKWAY, Technical Director
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Approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A prototype system was developed to evaluate a computer-assisted performance training carrel which was used to present the troubleshooting fundamentals lesson of the Lowry Technical Training Center's Electronic Principles Course. This manual provides a description of the PDP-11 and PLATO programs used to implement this system, and an operators guide for using the system. The PLATO data input system deletes characters from the data stream whenever more than about three characters per second are transmitted. In order to overcome this problem, the PDP-11 in the carrel is used to control all of the simulation, and transmits only the small amount of data necessary for monitoring the student's performance. The nature of the tables used in the simulation and the philosophy of the communications protocol are explained.

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SUMMARY

Problem

The objective of this study was to evaluate a computer assisted performance training carrel which was developed in-house at the Air Force Human Resources Laboratory, Technical Training Division, Lowry AFB, Colorado. The evaluation was realized by using the training carrel to deliver the troubleshooting fundamentals lesson from the Lowry AFB Technical Training Center's Electronic Principles Course. This report provides the documentation for the software necessary to present this course by controlling all required interaction between the student, a PDP-11 minicomputer, the PLATO system (via a PLATO terminal in the carrel) and a low-cost simulator. The hardware necessary to perform this task, and the subsequent course evaluation are described in AFHRL-TR-76-62 (I) and AFHRL-TR-76-62 (III), respectively.

Approach

The programming was divided into two main parts, one part written in TUTOR for the PLATO system, and one part written in machine language for the PDP-11. A second division was made between those parts of the program which were course specific, and those parts which were used for communication between the two computers.

Results

All of the simulation was done in the PDP-11 using tables of actual circuit values. The Standard Digital Equipment Corporation floating point package was used to do the arithmetic required to convert these values to meter deflections for the PSM-6 multimeter in the simulator. The PLATO computer was used for all of the testing, remediation, and monitoring functions in the course presentation. The bulk of textual material in the course was presented with the use of a study guide to avoid using expensive computer resources for a task better performed by using textual material. The TUTOR language had no provisions for interrupting a program with an external event, which forced considerable interaction between those parts of the program which were course specific, and those which were program specific.

Conclusions

The developed software adequately supported the evaluation program and provided insight to future techniques which could be employed for reliable instructional sequences. In addition, the program modules necessary to transfer data between the PDP-11, the simulator and the PLATO system were developed.

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SOFTWARE FOR PERFORMANCE TRAINING CARREL

I. INTRODUCTION

This system is designed to demonstrate and test the feasibility of using the performance training carrel for instructing students in the principles of electronics troubleshooting fundamentals using the PSM-6 multimeter. This course is normally taught as book 38 of the Electronic Principles course at Lowry Technical Training Center (LTTC). The system is designed to operate using the following hardware and software configuration:

Hardware: PLATO-IV central computer (currently at University of Illinois)

Performance Training Carrel equipped with
- Slide Projector
- PLATO-IV terminal
- DRI buss system
- 8k PDP-11/10 minicomputer
- PSM-6 simulator

Software:
- Slide set
- Set of Circuit Boards
- Study Guide and Workbook
- TUTOR program (CAMILI)
- PDP-11 program

This report is designed to provide operating instructions for the entire system, and to describe the program items listed previously. The following program descriptions assume that the reader is reasonably proficient in the use of the TUTOR language and PDP-11 assembly language.

II. TUTOR PROGRAM

The TUTOR program is designed to be used in conjunction with the study guide and workbook. The student starts the course by logging in at the carrel. He will be given an introduction to the system, then directed to the study guide. He is then directed to use the carrel, where he will be directed back to the study guide when he has completed the interactive instructional sequence. This is repeated as often as necessary. While the student is supposed to be working in the study guide, the PLATO display will be showing an index frame, which shows the areas of the course and which areas have been completed. An area of the course may consist of a CAI question, a slide presentation, or a performance training sequence using the PSM-6 simulator. Several areas may be executed during one instructional sequence. Any of the areas, as well as five unlisted maintenance areas, may be accessed from the index display by pressing the letter corresponding to the desired area.

The regular instructional sequence has no options other than the options common to all TUTOR functions. However, while in the index display, five diagnostic areas are available in addition to the course areas listed. To enter one of these areas, press the letter corresponding to the area listed in Table 1. To exit any of these segments, press -BACK-, which will return the program to the index display.

Table 1. **CAMIL1 Diagnostics Index**

v)	Alignment grid for touch panel and slide projector
w)	PDP-11/PLATO data transfer using SIM
x)	PDP-11/PLATO data transfers using SIMUL
y)	PDP-11/PLATO single data word transfers
z)	Display slides

Other than the program structuring mentioned previously, this program does not have any complex data structures. The variables used in the program, and their meanings, are listed in Table 2.

Table 2. **CAMIL1 Variable Names**

Variable Name		Segment Name	Description
n1	byt(1)	err	Error code from PDP-11.
	byt(2)	read	Value sent to D/A by PDP-11 for meter reading.
	byt(3)	sec	Time in seconds (mod 256) since PDP-11 program was started.
	byt(4)	probes	Probe locations. Refer to PDP-11 Program Description for explanation of how this variable is coded.
	byt(5)	funrang	Function/range switch settings.
	byt(6)	schem	Circuit board number from PDP-11.
	byt(7)		Not used.
n2	byt(8)	lasterr	Value of err from previous measurement.
	byt(9)	red	Test point number for red probe.
	byt(10)	black	Test point number for black probe.
	byt(11)	ludone	Area number for last course area completed.
	byt(12)	sch	Circuit board number set by SIM call.
	byt(13)	k	Counter used by SIMUL to fill byt(1) through byt(6).
	byt(14)	malf	Malfunction code set by SIM call.
n3	keycode		Internal value of key pressed during SIMUL (−1 if no key was pressed).
n4	loc		Display panel location for SIM displays, set by SIM call.
n5	udone(n)		A "1" in udone(n) indicates that area n has been completed.
N6,7	vmeas(n)		Used to record which voltage measurements have been made. If vmeas(n) = 1, then a voltage measurement has been taken such that PROBES = 2 * (n−1).
	vmeas(1)		Set to 1 when a visual inspection has been made.
n6	volts		Used to access the first 60 positions of vmeas.
n8,9	rmeas(n)		Used to record which resistance measurements have been made. If rmeas(n) = 1, then a resistance measurement has been taken such that PROBES = 2 * n.
n8	ohms		Used to access the first 60 positions of rmeas.
n10	tp(n)		Used to record which test points have been used in making measurements. If tp(n) = 1 then a measurement has been made with either the red or the black probe in TP_n.
n10	tps		Used to access all tp(n) positions simultaneously.

III. PDP-11 PROGRAM

The PDP-11 program reads the status of the simulator every 60th of a second, controls the lights and meter readings, and informs the TUTOR program whenever a new reading is made. The PDP-11 uses tables of values for each possible measurement to calculate the correct reading.

The program is event-driven by the line clock. When a zero transition is detected on the power line, a program interrupt occurs, and the program will interrogate the first word of the PSM-6 status register. The response from the PSM-6 causes an interrupt, which is used to read the status into the PDP-11, and interrogate the second status word. This procedure will be repeated until all three status words have been read into the PDP-11. The three status words are then compared with the status words which were read into the computer during the previous 60th of a second, and the status is ignored unless the words are identical. When two identical status readings occur, they are compared with the status readings used for the last set of PSM-6 meter readings. If no change has occurred, no new calculations are made. However, if a change has been made, then the new meter readings are calculated, using data from the various tables. The meter reading is not sent out immediately after it is calculated, but is stored in the PSM-6 output data word (PSM-6E), where it will be sent out with the following status interrogation. Hence there is a delay of approximately 1/20th of a second from the time the probe or switch position is changed until the time the meter reading changes; the events are summarized as follows.

(PSM-6 status changes)

1st line clock:	Read status, no further action.
2nd line clock:	Read status, compute new meter reading.
3rd line clock:	Change meter reading when PSM-6 is interrogated.

Whenever a new reading is taken (removing the probes from the circuit is not considered to be a new reading), the TUTOR program will be notified. This is controlled by the portion of the program which is not interrupt driven, since the transfer of the information about the reading takes several seconds. Since interrupts are invisible to the main program, the interrupt portion of the program signals that a new reading has been made by setting bit 15 of a PDP-11 variable which also contains the error character. The actual data transfer from the PDP-11 to TUTOR is performed by an interrupt-driven routine which will be described in the TUTOR/PDP-11 program interface description.

There are three tables for the meter readings relating to each malfunction. The first is a list of addresses for the second set of tables, ordered by circuit board number. The second table contains information about the circuit board, namely a list of addresses for the third set of tables, ordered by malfunction number, and a list of test point numbers, ordered by node numbers. The third table contains the offset to the resistance portion of the table, followed by the voltage portion of the table and the resistance portion of the table. The two words preceding the start of this table are the indicator values for power on and off, and a pointer back to the node number portion of the second table.

All numeric entries in the tables for volts and ohms, and for full-scale and mid-scale meter readings, consist of only the high-order word of the standard PDP-11 floating-point format.

The PDP-11 program has a diagnostic feature which is operated from the switch register. Switch register bit assignments are:

bit 15 = 1:	Use the switch register bits 0-3 for the malfunction code. Print the diagnostic information shown below whenever a new measurement is made.
bit 15 = 0:	The malfunction code is obtained from PLATO. The teletype will print a single (non-printing) character each time a new measurement is made.
bit 3 = 1:	Simulator off-line. Also force recalculation if bits 0-2 = 7.

bits 0-2:	Malfunction code:	0 is normal circuit conditions.
		1 is the first malfunction.
	(This is only code good for all ckt bds.)	
		2 is second malfunction.

All unused malfunction codes will show

a) both lamps off
b) all voltages zero
c) all resistances zero
d) probes = 2.

The PDP-11 diagnostic printout consists of 9 bytes, the first 6 of which are also sent to PLATO. Each byte is displayed as 3 octal digits:

Oxy	xxx	xxx	xxx	Ofr	xxx	Oxx	Oxx	xxx
Error code	D/A setting	Low byte, seconds counter	"PROBES"	Function/Range	Schematic	Red node	Black node	Ohms adjust A/D value

Error code:

=0 means no error has been detected.
x=1 means an invalid function or range has been used.
y=0 means no error other than above has been detected.
y=1 means the reading is downscale.
y=2 means the wrong scale has been selected (reads too far to left).
y=3 means the wrong scale has been selected (reads too far to right).
y=4 means an attempt has been made to read voltage with the power off.
y=5 means an attempt has been made to read resistance with the power on.
y=6 means an attempt has been made to read resistance without zeroing the ohmmeter.
y=7 should never occur.

PROBES: This is a code composed of both the red and black test point numbers, combined to allow access to a linear table in the PDP-11. The elements of the table are arranged with the first entry being the one for the red probe in TP1 and the black probe in TP2, the second entry with the probes reversed, etc., as shown in the following diagrams:

Red TP \ Black TP	1	2	3	4
1	0	2	6	16
2	4	0	12	22
3	10	14	0	26
4	20	24	30	0

or, dividing by 4:

Red TP \ Black TP	1	2	3	4
1	0			
2	1	0		
3	2	3	0	
4	4	5	6	0

The last diagram above illustrates how the value is generated. The lower triangular portion of the array is numbered from left to right, beginning with the second row. These values are then multiplied by two. The upper part of the array is similarly numbered from top to bottom, beginning with the second column and values are then multiplied by two. However, one is subtracted to distinguish them from the lower number sequence. Finally, all of the numbers are doubled so that the PDP-11 can use them as word offsets in its tables. The formulae are:

R .GT. B:	PROBES = 2 * ((R-1)*(R-2) + 2 * B))
R .LT. B:	PROBES = 2 * ((B-1)*(B-2) + 2 * R -1)
R .EQ. B:	PROBES = 0

where R is the test point number for the red probe, and B is the test point number for the black probe.

Function/Range: These two digits indicate the PSM-6 switch settings as follows:

function switch	range switch
0: Not used	0: Not used
1: 100 UA	1: .5
2: DCmA	2: 2.5 / x1
3: ohms	3: 10 / x10
4: DCV - 20 k /v	4: 50 / x100
5: DCV - 1 k /v	5: 250 / x1000
6: ACV	6: 500 / x10000
7: OUTPUT	7: 1000

Schematic: 2 * (circuit board number) + (1 if power switch is ON, else 0) Red and black nodes: The term nodes means the value which is returned by the simulator hardware, and corresponds to the physical test points, rather than the test point numbers on the circuit boards, which are always called "test points." The node numbers are:

0 = probe not touching anything
1 = probe touching simulator chassis
2 = probe touching the other probe
37 = invalid code

The other nodes are on the simulator chassis and are arranged in the following pattern:

	7	14	21	26	
3	10	15	22	27	33
4	11	16	23	30	34
5	12	17	24	31	35
6	13	20	25	32	36

IV. TUTOR/PDP-11 PROGRAM INTERFACE DESCRIPTION

Because of transmission problems, data may fail to be passed in either direction. Hence the interface between the two programs contains a considerable degree of redundancy. Whenever the PDP-11 is running, the PDP-11 will accept and process data received from TUTOR. However, TUTOR will only accept data from the PDP-11 when the ENABLE command has been given; i.e., when the program is executing the SIMUL section of the program. Typically, the TUTOR program enters the SIMUL section before a reading is made. As soon as SIMUL is entered, a word is sent to the PDP-11 specifying the malfunction to be used and the desired byte (the first) of information to be returned to TUTOR. When a measurement is made, the requested byte of information is sent back to TUTOR. TUTOR then requests the second byte of information, and it is returned, etc. until all six bytes of information about the measurement have been transferred. Since any one of these transfers may fail due to noise on the telephone line, TUTOR will wait one second after it has sent a request for data, and if no response is obtained, will send another request. This process will continue until a response is obtained. TUTOR sends a code to the PDP-11 to quit sampling the PSM-6 whenever the first byte of data is received from the PDP-11. This is done to give the student feedback about when he can and cannot make measurements by turning the ON-LINE light off. The PDP-11 will not modify the data being transmitted or the meter setting (even though the probes may be moved) until all of the data has been transmitted. Any actions made while data is being transferred (except the last) are not recorded.

V. INSTRUCTIONS FOR OPERATING THE CARREL

TO BEGIN:

Turn ON the DRI buss circuitry using the toggle switch located on the card nest at the back of the carrel.

Turn ON the PLATO-IV terminal:

1. Apply power using the rocker switch located on the panel on the right side of the back of the upper part of the carrel.
2. Activate the terminal by pressing the power-fail override button located just below the main power relay. The border of the display panel should light.
3. Reset the terminal's error circuitry by pressing the red, then the white unmarked rocker switches.

Turn ON the PDP-11 computer located under the front of the carrel:

1. All of the switches must be even with the trim on the front panel.
2. Turn the key-operated power switch ON by turning it one-quarter turn clockwise.
3. The RUN indicator should now be lighted. If it is not, then:
   a. Press LOAD ADDRESS.
   b. Press START.

LOG onto the TUTOR system.

TO QUIT:

Press SHIFT-STOP until the message "Press NEXT to begin" appears.

Turn OFF the PDP-11 by turning the key-operated power switch counterclockwise to its limit.

Turn OFF the PLATO terminal using the rocker switch located on the back panel.

Turn OFF the DRI buss circuitry using the toggle switch on the card nest.

To provide the programmer with debugging facilities, the PDP-11 program operates with the 10X restart capability enabled so that pressing CNTRL-P should return the program to ODT-11x. Refer to DEC-11 XPTSA-A-D for instruction on use of ODT.

REFERENCES

Kargo, D.W., & Steffen, D.A. *Performance training carrel for electronics principles course*. AFHRL-TR-76-62 (I). Lowry AFB, CO: Technical Training Division, Air Force Human Resources Laboratory, September 1976.

West, A.S., Wasmundt, K.C., Lantz, A.E., Steffen, D.A., & Miller, G.G. *Performance training carrel evaluation*. AFHRL-TR-76-62 (III). Lowry AFB, CO: Technical Training Division, Air Force Human Resources Laboratory, in press.

APPENDIX A: PDP-11 FLOW CHART

This flow chart for the PDP-11 program for the PSM-6 simulator includes only those parts of the PDP-11 program in the section titled "PSM-6" which actually activate the meter. The other portions of the program are coded such that a reasonably experienced programmer would have no serious difficulties understanding the program.

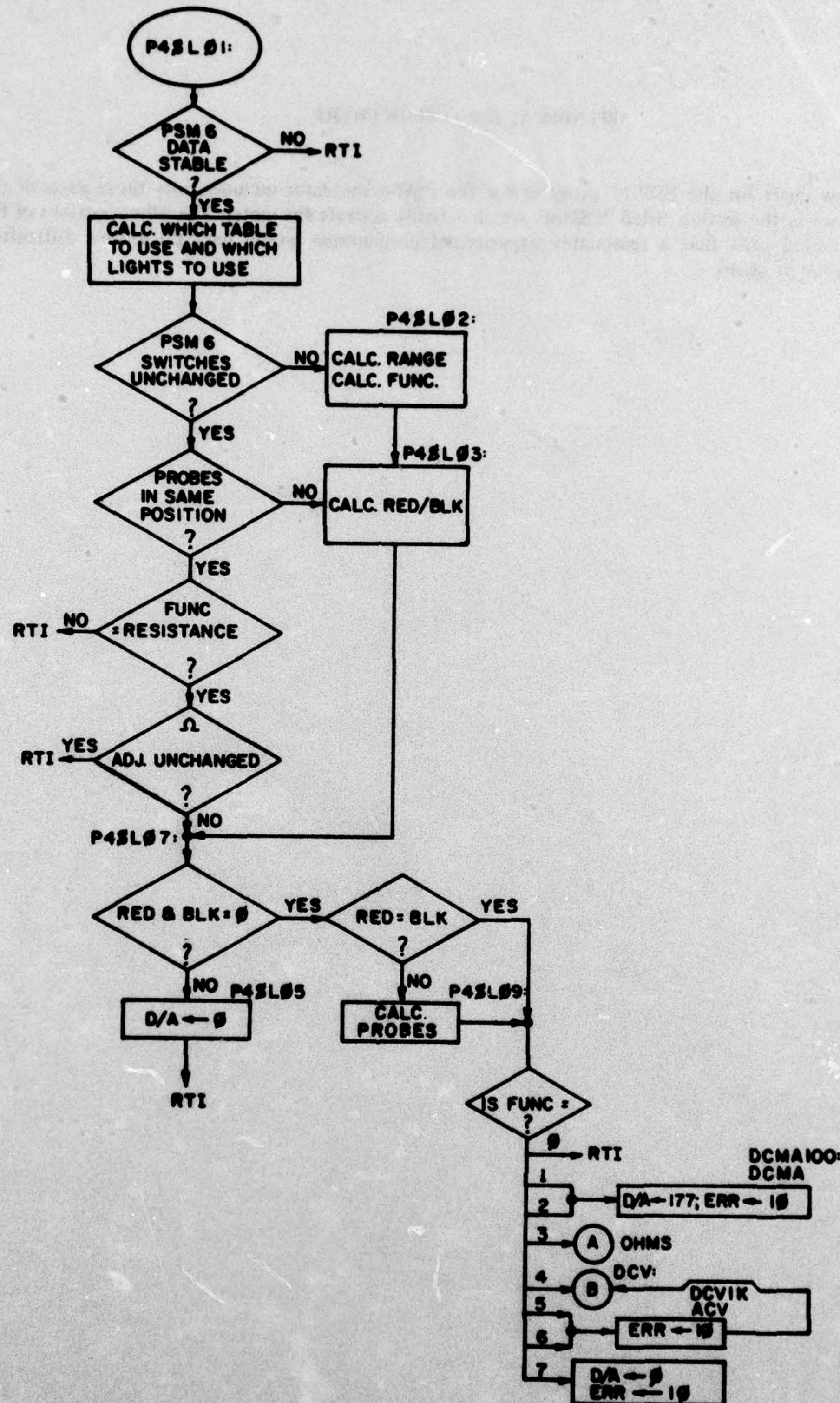

Figure A-1. **PDP-II flow chart.**

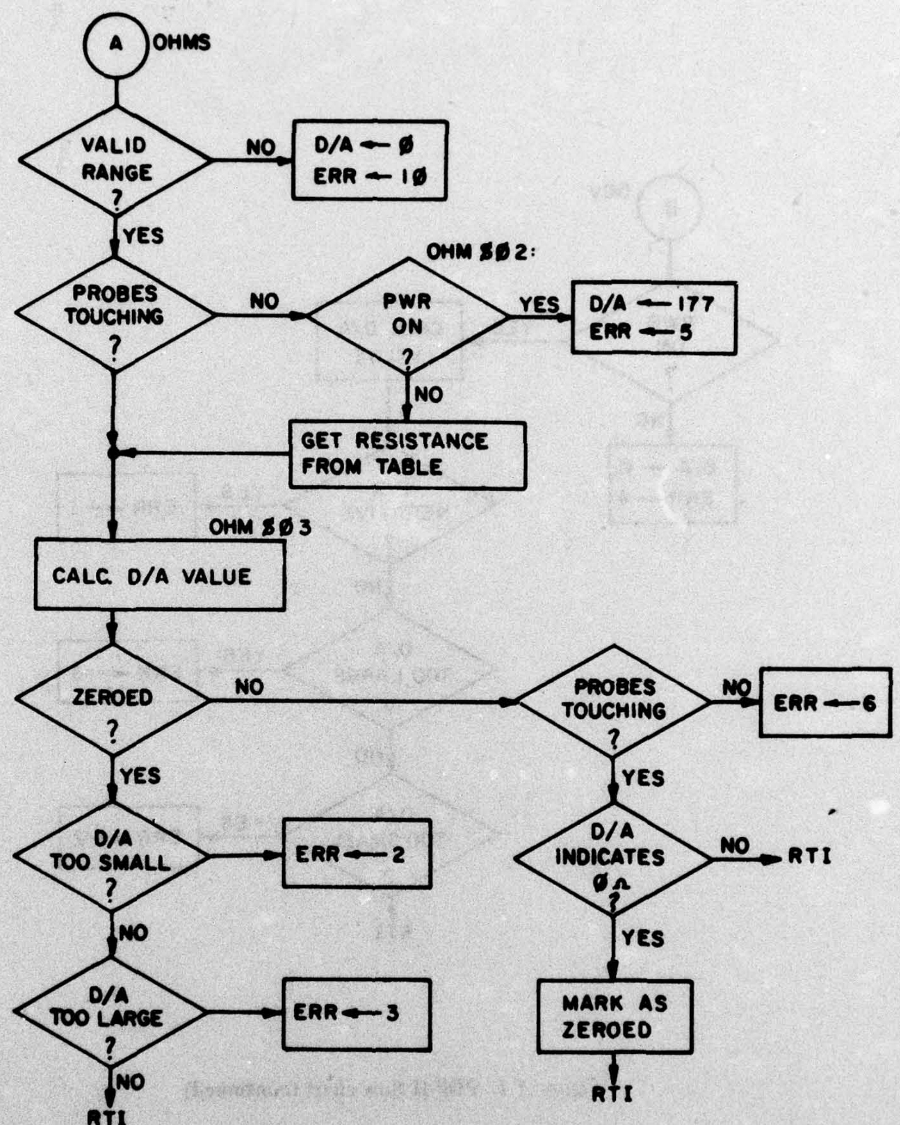

Figure A-1. **PDP-II flow chart (continued)**

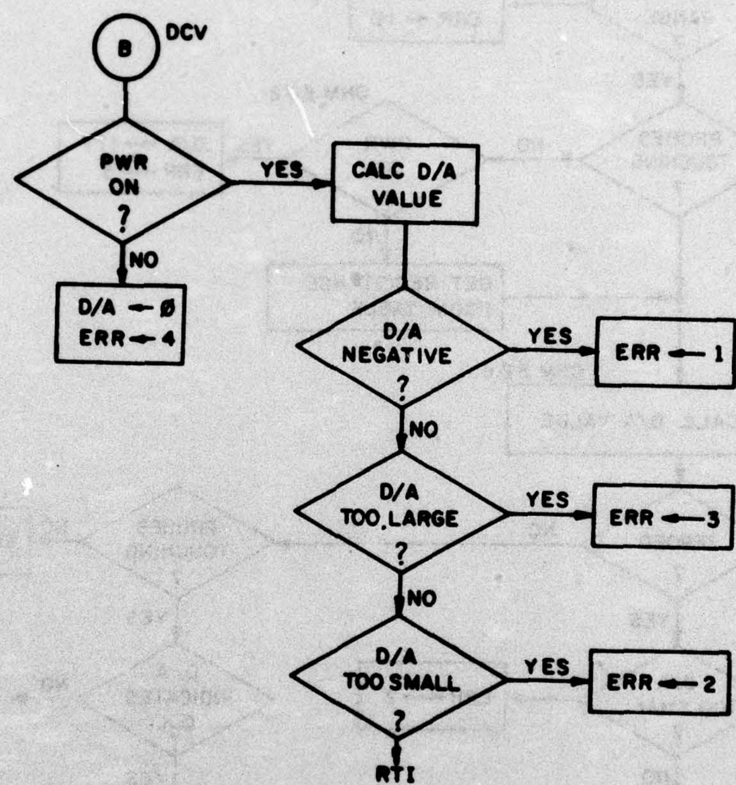

Figure A-1. **PDP-II flow chart (continued)**

APPENDIX B: TUTOR FLOW CHART

This flow chart is presented in an outline form which is intended to convey only the general flow of the program. Anyone desiring to acquire a detailed understanding of the program should use the flow chart in conjunction with the program listings.

The following notational conventions are used:

1. TUTOR commands are given in upper case; e.g., UNIT, SLIDE, etc. UNIT labels are given in lower case; e.g., fr1r refers to Frame 1 – Remedial.

2. The instructional areas are used to block the flow chart. Each AREA command is indicated by the corresponding lower-case designation used in the index display, followed by the AREA label.

3. A phrase in single quotes, '...', is a text which will be displayed on the plasma panel. In most cases, the actual text displayed has been condensed to shorten the flow chart.

4. A phrase in double quotes, "...", is a student response for TUTOR to match. Note that TUTOR allows various different forms of answers synonymous with the one given. Each of these answers is preceded by the associated TUTOR judgment (ok, no, wrong). Remember that, in general, TUTOR requires an OK judgment before exiting the ARROW loop.

5. A phrase in parentheses, (...), is a description of a condition which must be satisfied before the subsequent code is executed. Subsequent code is indented more than the outer block.

6. An equal sign following a HELP or DO unit label is used to describe a unit which consists of only a single slide. For example, HELP fr1r = SLIDE 29, means unit fr1r will only show slide 29.

7. Endsect (m,n) is used at the end of an instructional area to mark area n as complete for the index display. If m is shown as a number, then the program will actually call the unit labeled "endsect" and the message "Continue reading in your manual at page m" will be displayed. If m is shown as a hyphen, then the program coding is different, and the student will not see the above message.

8. SIM(m,n) specifies a program call on the unit labeled "sim," which activates the PSM-6 simulator, and provides general remedials for several kinds of errors (i.e., wrong function or scale, probes reversed, power switch settings which are not appropriate for the kind of measurement being made, ohms not zeroed, wrong circuit board, and measurements made before making a visual inspection). The schematic board used is to be number m, and n is the number for the malfunction which will be used. In the program, the calls on SIM include a third argument, loc, which is used to specify where messages are to be displayed.

9. A pair of numbers in parentheses, (m,n) is used to specify a measurement made with the red probe at test point m and the black probe at test point n. When resistance measurements are being made, the program contains provisions to allow for probe reversal.

The flow chart for the units SIM and SIMUL are shown in the conventional manner following the main flow chart (Figures B1 and B2). These units are used to connect the TUTOR code with the PDP-11 (SIM) and to give the student certain common types of remediation (SIMUL).

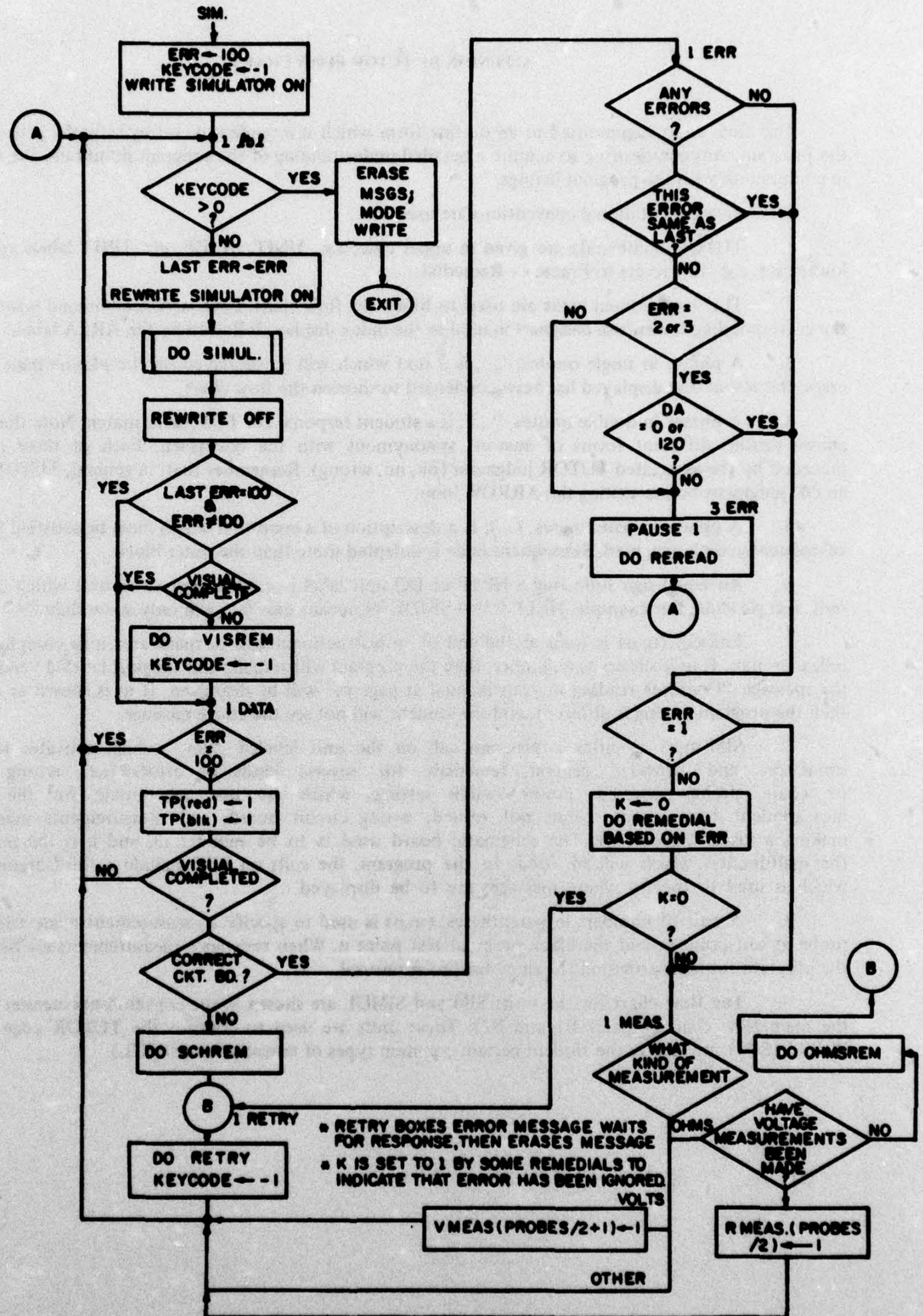

Figure B-1. **SIM flow chart**

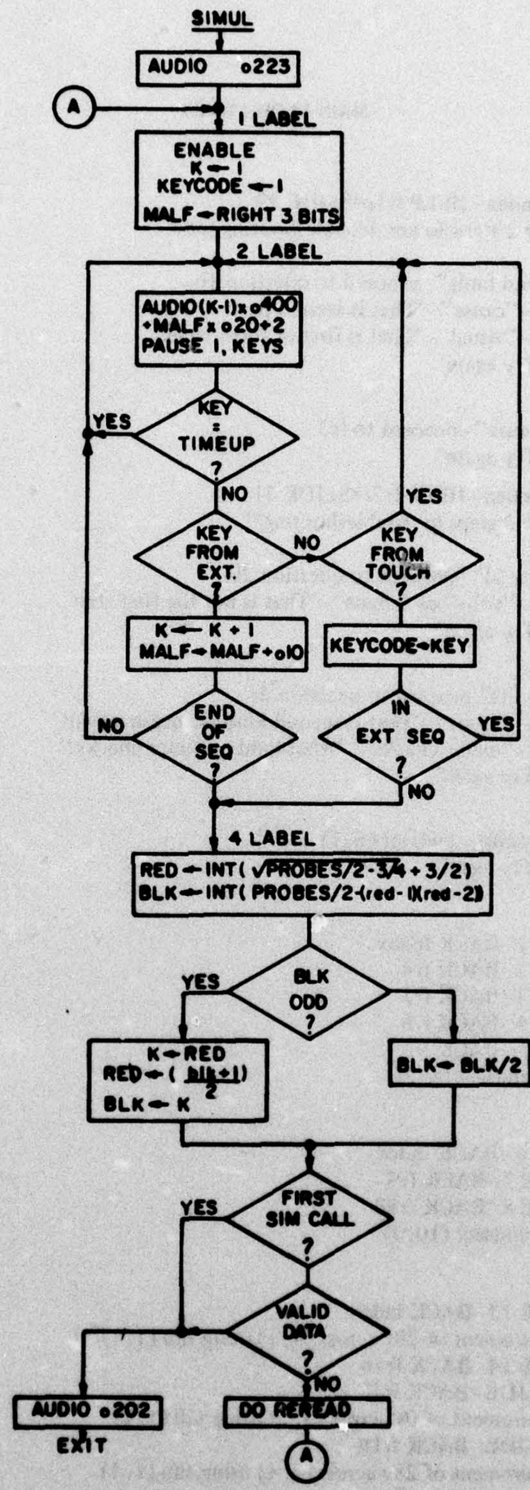

Figure B-2. **SIMUL flow chart**

MAIN FLOW CHART

(a) QUEST 1 & 2

UNIT fr1–BACK index–HELP fr1r=SLIDE 29
'What are the 2 steps to any troubleshooting job?'
Question 1a:
ok–"find fault"–proceed to question 1b.
wrong–"cause"–'That is second part'
wrong–"visual"–'That is first of three steps'
NO–'Try again'

Question 1b:
ok–"cause"–proceed to fr3
NO–'Try again'

UNIT fr3–BACK index–HELP fr3r=SLIDE 31
'What are the 3 steps in troubleshooting?'
Question 2a:
ok–"visual"–proceed to question 2b
wrong–"volts" or "ohms"–'That is not the first step'
NO–'Try again'

Question 2b:
ok–"volts" proceed to question. 2c
wrong–"ohms"–'That is second kind of measurement'
wrong–"meter checks"–'What kind of meter checks?'
NO–'Try again'

Question 2c:
ok–"ohms"–endsect (6, 1)
NO–'Try again'

(b) OPENS

UNIT fr4–SLIDE 1–BACK index.
UNIT fr5–SLIDE 2–BACK fr4
UNIT fr6–SLIDE 3–BACK fr5
UNIT fr7–SLIDE 4–BACK fr6
UNIT fr8–SLIDE 5–BACK fr7
PAUSE 20; endsect (8, 2)

(c) SHORTS

UNIT fr9–SLIDE 6–BACK index
UNIT fr10–SLIDE 7–BACK fr9
UNIT fr11–SLIDE 8–BACK fr10
PAUSE 20; endsect (10, 3)

(d) CKT 1-1

UNIT fr16–SLIDE 13–BACK index
Force measurement of 28v across (4, 1) using sim (1, 1).
UNIT fr17–SLIDE 14–BACK fr16
UNIT fr18–NOSLIDE–BACK fr17
Force measurement of 0v across (3, 2) using sim (1, 1).
UNIT fr19–NOSLIDE–BACK fr18
Force measurement of 28v across (2, 1) using sim (1, 1).
PAUSE 5; endsect (11, 4)

(e) **CKT 2-1**

UNIT fr20–**SLIDE** 15–**BACK** index
Force measurement of 12.5v across (2, 1) using sim (2, 1).
PAUSE 2p endsect (13, 5)

(f) **CKT 2-2**

UNIT fr21–**NOSLIDE**–**BACK** index
Force measurement 25v across (3, 2) using sim (2, 2).
UNIT fr21a–**NOSLIDE**–**BACK** index
Force measurement of 0v across (2, 1) using sim (2, 2).
Endsect (16, 6)

(g) **QUEST 3 & 4**

UNIT fr22–**SLIDE** 16–**BACK** index–**HELP** fr22r=**SLIDE** 17
ok–"b"–**DO** remedial if requested; proceed to fr23.
wrong–"a" or "c" or "d"–**DO** remedial
NO–'Answer a, b, c, or d'
UNIT fr23–**SLIDE** 18–**BACK** index–**HELP** fr23r=**SLIDE** 19
ok–"d"–**DO** remedial if requested; endsect (-, 7); proceed to fr24.
wrong–"a" or "b" or "c"–**DO** remedial.
NO–'Answer a, b, c, or d'

(h) **CKT 3-0**

UNIT fr24–**BACK** index–'Mount circuit board #3'
UNIT fr26–**SLIDE** 20–**BACK** fr24
Force measurement of 6.3v across DS_1 (6, 5) using sim (3, 0).
Force measurement of 10.8v across R_1 (2, 1) using sim (3, 0).
Force measurement of 10.8v across R_2 (5, 2) using sim (3, 0).
Force measurement of 10.0v across R_3 (3, 1) using sim (3, 0).
Force measurement of 2.0v across DS_2 (4, 3) using sim (3, 0).
Force measurement of 10.0v across R_4 (5, 4) using sim (3, 0).
Force measurement of 21.7v across parallel network (5, 1) using sim (3, 0).
Endsect (-, 8); simoff; GOTO fr33

(i) **CKT 3-1**

UNIT fr33–**SLIDE** 20–**BACK** fr24–'Now find malfunction'
UNIT fr33a–**SLIDE** 20–**HELP** fr33b
Wait for answer using sim (3, 1):
ok–"DS_1 shorted"–endsect (-, 9); JUMP fr34
wrong–"DS_1 open"–**DO** remopens; JUMP fr33b
NO–JUMP fr33b
UNIT fr33b–**SLIDE** 21–**HELP** via **BASE**
Force measurement of 0v across DS_1 (6, 5) using sim (3, 1).
PAUSE; endsect (-, 9); JUMP fr34

(j) **CKT 3-2**

UNIT fr34–**SLIDE** 20–**BACK** index–**HELP** fr34a=**SLIDE** 22
'Find different malfunction'; Wait for answer using sim (3, 2).
ok–"DS_2 shorted"–**DO** fr34b=**SLIDE** 23 if requested; endsect (18, 10)
wrong–"R1" or "R2"–'explain. . .';
wrong–"DS1"– 'explain. . .';
wrong–"F1 open"– 'explain. . .';
wrong–"R3" or "R4" **DO** fr34a=**SLIDE** 22.
"open"– 'explain. . .';
"short"– 'explain. . .';
wrong–"DS2 open"–**DO** remopens
NO–'Try again'

(k) QUEST 5

UNIT fr35–SLIDE 24–BACK index–HELP fr38
ok–"a"–DO fr38 if requested; endsect (21, 11)
wrong–"b"–DO fr37; DO fr38
wrong–"c" or "d"–DO fr38
NO–'Answer a, b, c, or d'
UNIT fr37–'NO. . .If R1 was open then . . .
UNIT fr38–'Blown fuse because of high current because DS1 shorted'

(l) QUEST 6

UNIT fr39–SLIDE 25–BACK index–HELP fr41
ok–"a"–DO fr41 if requested; endsect (27, 12)
wrong–"b" or "c" or "d"–DO fr41
NO–'Answer a, b, c, or d'
UNIT fr41–NOSLIDE–'Think about the symptoms'
PAUSE: SLIDE 26

(m) CKT 4-1

UNIT fr43–SLIDE 27–BACK index
UNIT fr45–NOSLIDE–BACK fr43–DATA vissch4
'Mount circuit board #4 on carrel'
Force measurement of 4.8v across (3, 5) using sim (4, 0)
Force measurement of 6.4v across (2, 5) using sim (4, 0)
Force measurement of 10v across (1, 5) using sim (4, 0)
Endsect (-, 13)

(n) CKT 4-1

UNIT fr45a–NOSLIDE–Clear measurement variables.
UNIT fr45b–NOSLIDE–BACK index–HELP fr48–DATA vissch4–BASE
'What is malfunction'; Wait for response using sim (4, 1)
"r2 open"–
ok–(measured at both TP2 and TP3)–JUMP fr50
wrong–(otherwise)–'You can't know that'
wrong–"R2 short"–DO remopens
wrong–"1vps"–DO 1vpsrem
NO–'Try again'
UNIT fr48–simoff
(measured at both TP2 and TP3)–JUMP fr49
(otherwise)–JUMP fr48end
UNIT fr48end
(visual inspection not completed)–DO vishelp; END help
(visual inspection completed)–'Try voltage checks'; END help
UNIT fr49–BASE
'You have made enough measurements to know'
Force measurement of open across R2 (2, 3) using sim (4, 1)
wrong–"short"–DO remmeter
Endsect (-, 14); JUMP fr53
UNIT fr50
(not measured at either TP2 or TP3)–'You can't know that';
Force measurement of 10v across R2 (2, 3) using sim (4, 1)
Endsect (-, 14); JUMP fr53

(o) CKT 4-2

UNIT fr53–NOSLIDE–Clear measurement variables;
'Now find new malfunction'; JUMP fr53a

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        UNIT    fr53a–NOSLIDE–BACK index–HELP fr48x–DATA vissch4–BASE
                'What is malfunction'; Wait for response using sim (4, 2)
                        ok–"R2 shorted"–JUMP fr50x
                        wrong–"R2 open"–DO remopens
                        wrong–"1vps"–DO 1vpsrem
                        NO–'Try again'
        UNIT    fr48x–simoff
                (measurements at both TP2 and TP3)–JUMP fr54
                (otherwise)–JUMP fr48end
        UNIT    fr50x
                (no measurement at either TP2 or TP3)
                        Force measurement of short across R2 (2, 3) using sim (4, 2)
                                wrong–"open"–DO remmeter
                'Good'; simoff; PAUSE; endsect (-, 15); JUMP fr55
        UNIT    fr54
                'You have enough measurements to know'
                Force measurement of short across R2 (2, 3) using sim (4, 2)
                        wrong–"open"–DO remmeter
                Endsect (-, 15); JUMP fr55

(p)     CKT 5-1

        UNIT    fr55–Clear measurement variables; 'Mount circuit board #5'
        UNIT    fr55a–NOSLIDE–BACK index–HELP fr55help–DATA vissch5–BASE
                'What is malfunction?'; Wait for response using sim (5, 1)
                        ok–"R1 shorted"–JUMP fr65
                        wrong–"Fuse"–DO fr56
                        wrong–"R1 open"–DO remopens
                        NO–'Try again'
        UNIT    fr55help
                (visual not performed)–DO vishelp; END help
                (No resistance readings)–'Try resistance measurements'; END help
                (Resistance of R1 measured)–'You know R1 is shorted'; END help
                (Otherwise)–
                        Force measurement of short across R1 (1, 2) using sim (4, 2)
                                wrong–"open"–DO remmeter
                        END help
        UNIT    vishelp–'Try making a visual inspection'
        UNIT    fr56–'Fuse is only a symptom'; PAUSE; JUMP fr55a
        UNIT    fr65–
                (Resistance of R1 measured)–'Good'; SLIDE 28; PAUSE; endsect (29, 16)
                (Otherwise)–'You can't know that'; PAUSE; JUMP fr55a

(q)     UNIT    fr66end–BACK index
                'This is the end of the lesson'; END LESSON
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