IDENTIFICATION

Product Code:	MAINDEC-08-D1L0
Product Name:	Basic PDP-8, 8/I Memory Checkerboard
Date Created:	June 10, 1968
Maintainer:	Diagnostics Group
Author:	J. W. Richardson

1. ABSTRACT

The PDP-8, 8/I Memory Checkerboard diagnostic tests memory for core failure on half-selected lines under worst case conditions. Its use is intended for basic 4K memory systems.

2. REQUIREMENTS

2.1 Equipment

A standard PDP-8 or 8/I

2.2 Storage

There are two versions of this MAINDEC. The Low End program occupies locations 0005 through 0150 octal, and tests memory from 151 through 7700 octal.

The High End program occupies locations 7430 to 7573 octal, and tests memory from 0000 to 7400 octal.

2.3 Preliminary Programs

The RIM loader must be in locations 7756 through 7776 octal.

3. LOADING PROCEDURE

3.1 Method

Load the program with the RIM loader.

a. Turn off the Teletype reader.

b. Set the SWITCH REGISTER to 7756.

c. Press LOAD ADDRESS, and then START.

d. Place the program tape in the reader and turn on the reader.

e. When the program has been loaded, stop the computer, turn off the reader, and remove the tape.

4. STARTING PROCEDURE

4.1 Starting Addresses

0005 Low End Checkerboard

7430 High End Checkerboard

4.2 Control Switch Settings

One of the four possible patterns that can be written in memory is obtainable by each of the following SR settings:

a. 0100 This setting is ued for the standard PDP-8 core unit.

b. 0101 This setting is used for the standard PDP-8/I core unit.

c. 0000 } These are for special core units from other suppliers.
d. 0001 }

4.3 Operator Action

With the program in memory, set the SWITCH REGISTER to the starting address, 0005 for Low End or 7430 for High End.

Press LOAD ADDRESS.

Set the SWITCH REGISTER to one of the four settings given in Paragraph 4.2 to obtain the correct pattern. For most PDP-8's, this will be 0100. For most PDP-8/I's, the setting will be 0101.

Press START.

The program will run until an error is detected, or stopped by the operator.

5. OPERATING PROCEDURE

5.1 Operational Switch Settings

See Paragraph 4.2

5.2 Subroutine Abstracts

The program writes the selected pattern into the area of memory to be tested.

The contents of each word are then read, complemented, and written back into the same location, until the contents of the entire area have been complemented. This procedure is repeated 14 times before the contents of each word is checked for incorrect bits.

Error checking begins by reading a location and checking for incorrect bits.

The contents are complemented, written back into the same location, and rechecked for incorrect bits.

The original contents are returned to the location, and the next sequential location is then checked.

After all of memory is tested, the program writes the complement of the pattern and proceeds to check as before.

5.3 Operator Action

See Paragraph 4.3

6. ERRORS

Any location containing an incorrect bit will create an error halt when detected by the program. The contents of a given memory location should always be 0000 or 7777. Anything other than 0000 or 7777 will result in an error halt.

6.1 Error Halts and Description

Two halts are provided for each error, and are described below. Two addresses are given for each halt; the first is for the Low End Test, and the second for the High End Test.

C(MA)	Tag	Description
0124 7546	E1	A memory location does not contain 7777 or 0000. The AC displays the contents of the location in error.
0127 7551	E1A	The AC displays the address of the location in error.

6.2 Error Recovery

Tag	Operator Action
E1	Record the C(AC). Press CONTINUE to reach the next halt.
E1A	Record the C(AC). Press CONTINUE to resume testing with the next sequential memory location.

7. RESTRICTIONS

7.1 Starting Restrictions

None

7.2 Operating Restrictions

None

8. MISCELLANEOUS

8.1 Execution Time

The time to write and test any pattern and its complement is approximately 3 seconds.

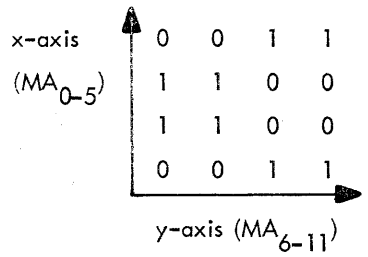
9. PROGRAM DESCRIPTION

In a standard core plane, a given core is selected when the combined currents of the x- and y-selection lines produce a magneto motive force which exceeds the threshold for reversing the flux direction of the core. This occurs at the intersection of the activated selection lines. All other cores which are threaded onto the activated lines will be slightly disturbed. Under marginal voltage conditions, such half-selected cores might also reverse polarity if their states are properly established by the pattern which the Checkerboard Test writes into memory.

When a selected core is in the 1 state, the read current will cause it to reverse polarity and become 0. When the core is in the 0 state, the write current will cause it to become 1. Thus, the possibility of a reading error is greatest when all the half-selected cores are in the 1 state; a writing error is most probable when all the half-selected cores are in the 0 state.

If a half-selected core changes polarity, the error will be detected when the memory register containing that core is tested by the program. For a reading error, the contents of that core will appear as a 0 in a field of 1's, and vice versa for a writing error.

Every Checkerboard Test pattern consists of alternating pairs of memory cells; one pair containing 7777's the other containing 0000's. Since memory manufacturers wire their core stacks in different ways, the same pattern of alternations cannot be used for every type of core, and still allow a "worst case" condition, that is, one in which all half-selected cards undergo the greatest possible disturbance which can occur when testing memory. The following pattern is used for the Ferroxcube memories with which most PDP-8's are provided.



Since the y-axis selection lines are conditioned by the low-order six bits of the memory address register (MA_{6-11}), and the x-axis lines by the high-order bits (MA_{0-5}), the above array is interpreted as follows: (x- and y-axis should be interpreted as shown above).

Positions on the x-axis represent consecutive locations in memory from 00 through 77.

Positions on the y-axis represent consecutive 100_8's. Thus, the lower left corner represents location 0000. This position contains a 0, which means that the contents of the entire memory cell at address 0000 are 0; likewise, the contents of memory cell 0201 are 1's or 7777. This is determined by reading the third row up on the x-axis, and across one position on the y-axis.

The pattern in memory appears as follows:

Address	Contents
0000	0000
0001	0000
0002	7777
0003	7777
0004	0000
0005	0000
0006	7777
0007	7777
....	....

The pattern matrix, shows that after 77_8 registers, the pattern will reverse itself, thus:

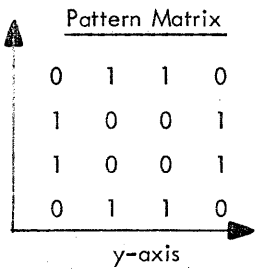
Address	Contents
0076	7777
0077	7777
0100	7777
0101	7777
0102	0000
0103	0000
0104	7777
0105	7777
0106	0000
0107	0000
....	....

and so on through memory. The pattern reverses every 100_8 registers.

The patterns generated by the other three switch register settings are defined by the following pattern matrices.

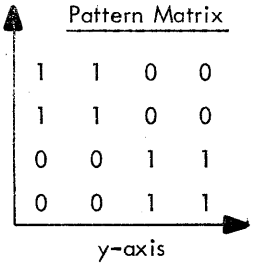
SR Setting

0101



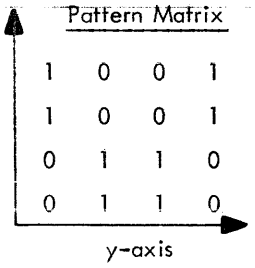
SR Setting

0000



SR Setting

0001



JUN 3

```
                        /MAINDEC 802:   PDP-8 CHECKERBOARD
                        /
      0001              *1
0001  5001                       JMP .
0002  0002                       0002
0003  0003                       0003
                        /
      7430              *7430

7430  7121                       CLL CML IAC     /HIGH END TEST
7431  3361                       DCA COM
7432  1366                       TAD JMP1
7433  3265                       DCA STD-2

7434  7604              STX,     LAS
7435  3362                       DCA PAT
7436  3363                       DCA SA

7437  2361              STB,     ISZ COM
7440  1361                       TAD COM
7441  0357                       AND DOT         /2
7442  7640                       SZA CLA
7443  1356                       TAD NOT         /10
7444  1355                       TAD HOT
7445  3254                       DCA Y           /COMPLEMENT THE PATTERN

7446  1354              STC,     TAD SOT         /400
7447  1363                       TAD SA          /TEST FORFINAL ADDRESS
7450  7650                       SNA CLA
7451  5232                       JMP STX-2
7452  1362                       TAD PAT
7453  0353                       AND ROT         /200

7454  0000              Y,       0
7455  1356                       TAD NOT         /10-Y LINE PRESETS
7456  1355                       TAD HOT         /X LINE TO SNA OR SZA
7457  3262                       DCA X
7460  1362                       TAD PAT
7461  0357                       AND DOT         /2

7462  0000              X,       0
7463  7040                       CMA
7464  7420                       SNL
7465  5276                       JMP DOALL
7466  3763                       DCA I SA                /STORE PATTERN AND THE COMPLEMENT

7467  2363              STD,     ISZ SA          /WORD WHEN CHECKING
7470  2362                       ISZ PAT
7471  1363                       TAD SA
7472  0352                       AND BOT         /77
7473  7650                       SNA CLA
7474  5240                       JMP STC
7475  5260                       JMP X-2
```

```
                        /
                        /READ AND COMPLEMENT 128 TIMES BEFORE TEST.
                        /
7476  3364              DOALL,  DCA WRD          /SAVE DATA
7477  1360                      TAD M17
7500  3365                      DCA LOOP                /LOOP COUNTER
7501  3363                      DCA SA           /ADDRESS COUNTER
7502  1763              LALL,   TAD I SA                /READ
7503  7040                      CMA              /COMPLEMENT
7504  3763                      DCA I SA                /WRITE BACK
7505  1354                      TAD SOT          /400
7506  1363                      TAD SA
7507  7650                      SNA CLA          /ADDRESS=//00 IF NO SKIP
7510  5313                      JMP .+3
7511  2363                      ISZ SA           /INCREMENT ADDRESS
7512  5302                      JMP LALL                /LOOP
                        /
7513  2365                      ISZ LOOP                /128 TIMES WHEN SKIP
7514  5301                      JMP LALL-1       /LOOP
7515  1367                      TAD JMP2                /JMP2=JMP CCK
7516  3265                      DCA STO-2
7517  3363                      DCA SA
7520  1364                      TAD WRD
                        /
7521  3364              CCK,    DCA WRD          /CHECK PATTERN
7522  1763                      TAD I SA
7523  7041                      CMA IAC
7524  1364                      TAD WRD
7525  7640                      SZA CLA
7526  5342                      JMP CC3          /ERROR IN CORE
7527  1364                      TAD WRD
7530  7040                      CMA
7531  3763                      DCA I SA                /COMPLEMENT THE WORD
7532  1763                      TAD I SA                /IN CORE
7533  7001                      IAC
7534  1364                      TAD WRD
7535  7640                      SZA CLA          /TEST COMPLEMENT WORD
7536  5342                      JMP CC3          /ERROR
7537  1364              CC2,    TAD WRD
7540  7100                      CLL
7541  5266                      JMP STO-1
7542  1763              CC3,    TAD I SA
7543  7402              E1,     HLT              /ERROR;AC CONTAINS
7544  7200                      CLA              /INFORMATION IN ERROR
7545  1363                      TAD SA
7546  7402              E1A,    HLT              /AC CONTAINS ADDRESS OF
7547  7300                      CLA CLL          /REGISTER IN ERROR
7550  7300                      CLA CLL
7551  5337              CC4,    JMP CC2
```

```
7552  0077          BOT,    //
7553  0200          ROT,    200
7554  0400          SOT,    400
7555  7640          HOT,    7640
7556  0010          NOT,    10
7557  0002          DOT,    2
7560  7760          M17,    7760
7561  0000          COM,    0               /VARIABLES
7562  0000          PAT,    0
7563  0000          SA,     0
7564  0000          WRD,    0
7565  0000          LOOP,   0
7566  5270          JMP1,   JMP DOALL
7567  5521          JMP2,   JMP CCK
                    $
```

THERE ARE NO ERRORS

SYMBOL TABLE

BOT	7552
CCK	7521
CC2	7537
CC3	7542
CC4	7551
COM	7561
DOALL	7476
DOT	7557
E1	7543
E1A	7546
HOT	7555
JMP1	7566
JMP2	7567
LALL	7502
LOOP	7565
M17	7560
NOT	7556
PAT	7562
ROT	7553
SA	7563
SOT	7554
STB	7437
STC	7446
STD	7467
STX	7434
WRD	7564
X	7462
Y	7454

SYMBOL TABLE

SIX	7454
SIB	7457
SIC	7446
Y	7454
X	7462
SID	7467
DOALL	7476
LALL	7502
CCK	7521
CC2	7537
CC3	7542
E1	7543
E1A	7546
CC4	7551
BOT	7552
ROT	7553
SOT	7554
HOT	7555
NOT	7556
DOT	7557
M17	7560
COM	7561
PAT	7562
SA	7563
WRD	7564
LOOP	7565
JMP1	7566
JMP2	7567

```
                    /PDP-8 CHECKBOARD REV., JAN., 1968
                    /COPYRIGHT 1969, DIGITAL EQUIPMENT CORP., MAYNARD, MASS.
                    /
          0001      *1                  /LOW END TEST
                    /
0001  5041                 JMP       .
0002  0002                 0002
0003  0003                 0003
0004  0000                 0
0005  7121                 CLL CML IAC
0006  3144                 DCA       COM
0007  1147                 TAD       JMP1
0010  3244                 DCA       STD=2

0011  7624      STX,       LAS
0012  1146                 TAD       MUD
0013  3141                 DCA       PAT
0014  1146                 TAD       MUD
0015  3143                 DCA       SA

0016  2144      STB,       ISZ       COM
0017  1144                 TAD       COM
0020  0136                 AND       DOT               /2
0021  7640                 SZA CLA
0022  1135                 TAD       NOT               /10
0023  1132                 TAD       HOT
0024  3033                 DCA       Y                 /COMPLEMENT THE PATTERN

0025  1134      STC,       TAD       POT               /100
0026  1143                 TAD       SA                /TEST FOR FINAL ADDRESS
0027  7650                 SNA CLA
0030  5007                 JMP       STX=2
0031  1141                 TAD       PAT
0032  0133                 AND       ROT               /200

0033  0000      Y,         0
0034  1135                 TAD       NOT               /Y LINE PRESENTS X LINE
0035  1132                 TAD       HOT               /TO SNA OR SZA
0036  3041                 DCA       X
0037  1141                 TAD       PAT
0040  0136                 AND       DOT               /2

0041  0000      X,         0
0042  7040                 CMA
0043  7420                 SNL
0044  5055                 JMP       DOALL
0045  3543                 DCA I     SA                /STORE PATTERN AND RECOMPLEMENT

0046  2143      STD,       ISZ       SA                /WORD WHEN CHECKING
0047  2141                 ISZ       PAT
0050  1143                 TAD       SA
0051  0137                 AND       BOT               //7
0052  7650                 SNA CLA
0053  5025                 JMP       STC
```

0054 5037 JSP X=2

```
                        /
                        /READ AND COMPLEMENT 128 TIMES BEFORE TEST.
                        /
0055  3145    DOALL,    DCA     WRD             /SAVE DATA
0056  1140              TAD     M1/
0057  3142              DCA     LOOP            /LOOP COUNTER
0060  1146              TAD     MUD             /END OF PROGRAM+1
0061  3143              DCA     SA              /ADDRESS COUNTER
0062  1543    LALL,     TAD I   SA              /READ
0063  7240              CMA                     /COMPLEMENT
0064  3543              DCA I   SA              /WRITE BACK
0065  1134              TAD     POT             /64 DECIMAL
0066  1143              TAD     SA
0067  7650              SNA CLA                 /ADDRESS=7700 IF NO SKIP
0070  5073              JMP     .+3
0071  2143              ISZ     SA              /INCREMENT ADDRESS
0072  5062              JMP     LALL            /LOOP
                        /
0073  2142              ISZ     LOOP            /128 TIMES WHEN SKIP
0074  5060              JMP     LALL-2          /LOOP
0075  1150              TAD     JMP2            /JMP2=JMP CCK
0076  3044              DCA     STD-2
0077  1146              TAD     MUD
0100  3143              DCA     SA
0101  1145              TAD     WRD
```

```
0122  3145  CC4,    DCA      WRD             /CHECK PATTERN
0123  1543          TAD I    SA
0124  7041          CMA      IAC
0125  1145          TAD      WRD
0126  7640          SZA CLA
0127  5123          JMP      CC3             /ERROR IN CORE
0130  1145          TAD      WRD
0131  7240          CMA
0132  3543          DCA I    SA              /COMPLEMENT THE WORD
0133  1543          TAD I    SA              /IN CORE
0134  7041          IAC
0135  1145          TAD      WRD
0136  7640          SZA CLA                  /TEST COMPLEMENT WORD
0137  5123          JMP      CC3             /ERROR

0140  1145  CC2,    TAD      WRD
0141  7100          CLL
0142  5045          JMP      STD-1

0143  1543  CC3,    TAD I    SA              /ERROR: AC CONTAINS INCORRECT WORD,
0144  7402  E1,     HLT
0145  7200          CLA
0146  1143          TAD      SA              /AC CONTAINS ADDRESS OF
0147  7402  E1A,    HLT                      /REGISTER IN ERROR
0150  7300          CLA CLL

0151  5140  CC4,    JMP      CC2

0152  7640  HDT,    7640                     /CONSTANTS
0153  0200  RDT,    200
0154  0100  PDT,    100
0155  0010  NDT,    10
0156  0002  DDT,    2
0157  0077  BDT,    77
0160  7700  M1,     7700
0161  0000  PAT,    0                        /VARIABLES
0162  0000  LOOP,   0
0163  0000  SA,     0
0164  0000  COM,    0
0165  0000  WRD,    0
0166  0171  MOD,    .+3
0167  5055  JMP1,   JMP DOALL
0170  5102  JMP2,   JMP CCK
```

```
BOT     0137
CC2     0120
CC3     0123
CC4     0131
CCK     0122
COM     0144
DOAL_   0055
DOT     0136
E1      0124
E1A     0127
HOT     0132
JMP1    0147
JMP2    0150
LALL    0062
LOOP    0142
M17     0140
MUL     0146
NOT     0135
PAT     0141
POT     0134
ROT     0133
SA      0143
STB     0016
STC     0025
STD     0046
STX     0011
WRD     0145
X       0041
Y       0033
```

ERRORS DETECTED: 0

LINKS GENERATED: 2

RUN-TIME: 3 SECONDS

4K CORE USED