

IDENTIFICATION

Product Code: MAINDEC 15-DIAØ-D (D)
Product Name: PDP-15 Basic Memory Checkerboard
(Low and High Versions)
Date Created: October 22, 1969
Maintainer: Diagnostics Group
Author: J. W. Richardson



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1. ABSTRACT

The PDP-15 Basic Memory Checkerboard programs test 3D core memories for failure on half-selected lines under worst case noise conditions. Their use is intended for 4K systems. Either program will loop until stopped by the operator, or an error is detected.

2. REQUIREMENTS

Equipment

A standard PDP-15.

Storage

There are two versions of this MAINDEC. The Low End program occupies memory locations 200 to 506, and tests memory from 1000 to 7777 octal. The High End program occupies locations 7400 to 7674, and tests memory from 0000 to 7377 octal.

3. LOADING PROCEDURE

The loading procedure is identical for either program.

- a. Place the tape in the reader.
- b. Place the BANK MODE switch on a 1.
- c. Set the ADDRESS switches to 17700.
- d. Press I/O RESET, and then READ-IN.

4. STARTING PROCEDURE

- a. 200 is the starting address for the Low End program.
- b. 7400 is the starting address for the High End program.
- c. The AC switches do not effect the normal operation of the program. However, they may be used to suppress error halts. See section 6.

5. PROGRAM DESCRIPTION

The program tests memory using four different patterns. Three of the patterns are variations of a checkerboard type, plus the complement of each, making a total of six. The fourth pattern is included to test the effects of prolonged reading of a memory location that contains 000000 and all other intersecting addresses contain 777777. As an example, the program may write 777777 in every Y axis address from 0000 through 7300. The Y axis is addressed using bits 6 - 11. The program then deposits 000000 in address 0000 and then reads (LAC*) address 0000 1024 times. Each Y address intersecting X line 00 is then read and checked to make sure that each contains 777777. If a "weak" core is present, it may switch to the 0 state using this test method.

Shown below are the three checkerboard patterns and their complements as they would appear in a portion of one bit plane. Each pattern complements every 40 octal addresses. The X axis is addressed by MA bits 12 - 17, and the Y axis by bits 6 - 11.

Pattern 1: 463144

Y axis		Y axis	
0	10011001	0	01100110
X axis	10011001	X axis	01100110
	⋮		⋮
40	01100110	40	10011001

Pattern 2: 631460

Y axis		Y axis	
0	11001100	0	00110011
X axis	11001100	X axis	00110011
	⋮		⋮
40	00110011	40	11001100

Pattern 3: 525250

Y axis		Y axis	
0	10101010	0	01010101
X axis	10101010	X axis	01010101
	⋮		⋮
40	01010101	40	10101010

The control words used to generate the patterns are:

Pattern 1: 463144 and 314633

Pattern 2: 631460 and 146317

Pattern 3: 525250 and 252527

6. ERROR HALTS

Listed below are the six possible halts which may occur. Halts E1 through E4 apply to the memory checkerboard tests (patterns 1, 2 and 3), and E5 and E6 are used for the fourth pattern (tagged BURST on the program listing).

Two addresses are given for each halt; the first is for the Low End test and the second for the High End test.

<u>C (MO)</u>	<u>Tag</u>	<u>Description</u>
362 7557	E1	A memory location does not contain 777777 or 000000. The AC displays the address of the location in error. Press CONT for next halt.
364 7561	E2	The AC displays the contents of the location in error. Record the value and press CONT for the next halt.
366 7563	E3	The AC displays the data the location should have contained. Press CONT again.
370 7565	E4	The AC displays the control word used to generate the current checkerboard pattern. The value will equal 463144, 631460 or 525250 or their complements - 314633, 146317 or 252527. Press CONT resume testing with the next sequential memory location.
450 7643	E5	An error was detected during pattern 4. A memory location does not equal 777777. The AC displays the failing address. Bits 12 - 17 indicate the X axis address which contains 000000. Bits 6 - 11 indicate the Y axis address which should have contained 777777. Press CONT for the next halt.

<u>C (MO)</u>	<u>Tag</u>	<u>Description</u>
452 7645	E6	The AC displays the data read from the failing address. Press CONT to test the next sequential Y axis address.

Error Suppression

Further error halts for any bit position in the checkerboard tests (halts E1 - E4) may be suppressed by placing the corresponding AC switch on a 1 before pressing CONT after the last error halt (E4). An error halt will occur for any failing bit position whose corresponding AC switch is on a 0. Error halts for all bit positions may be restored by restarting from 200 (Low) or 7400 (High).

Any one of the six checkerboard patterns (3 plus complements) may be used exclusively by placing the correct control word in 3 locations (see error halt E4 above). For the Low End test these locations are 460, 461 and 462. For the High End test the locations are 7671, 7672 and 7673. Either set of 3 locations normally contain 463144, 631460 and 525250, respectively.

Error suppression for pattern 4 is not provided. To loop on any failing address do the following:

1. Manually DEPOSIT the failing address in the location tagged PATR on the listing.
2. Place a NOP 2 locations before the tag BUST (BUST -2).
3. Set the ADDRESS switches to the address of tag BRSTA. Press I/O RESET, and then START.

The location tagged PATR contains the failing address.

Location BUST -2 normally contains an ISZ PATWD.

7. EXECUTION TIME

Either program requires approximately 20 seconds to run all 7 patterns.

8. LISTING

.TITLE LOCK 15

/
 /PDP-15 BASIC 4K MEMORY CHECKERBOARD,
 /S.A.=200. (RESIDES IN LOW - TESTS HIGH)
 /
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 /MAYNARD, MASS.
 /
 /J. RICHARDSON
 /

```

      .ABS
00200      .LOC 200
/
00200      777777      BEGIN      LAW      -1
00201      040453      DAC      BITSUP
00202      777775      LAW      -3
00203      040454      DAC      PATCNT      /CONTROL WORD COUNT
00204      200456      LAC      PATN      /CONTROL WORD POINTER
00205      040457      DAC      NXTPAT
/
00206      220457      CKLP      LAC*     NXTPAT      /GET A CONTROL WORD
00207      040465      DAC      CNTRL      /SAVE
00210      100215      JMS      TEST      /WRITE PATTERN AND TEST
00211      440457      ISZ     NXTPAT      /INCREMENT POINTER
00212      440454      ISZ     PATCNT      /DONE ALL IF SKIP
00213      600206      JMP      CKLP      /DO NEXT PATTERN
00214      600202      JMP     BEGIN+2    /START OVER
/
00215      000000      TEST     0
00216      100263      JMS     WRITE      /WRITE THE PATTERN
00217      200471      LAC     K1
00220      040470      DAC     BITCON     /USED TO COMPLEMENT BITS
00221      100270      JMS     READ      /READ AND TEST
00222      200470      LAC     BITCON
00223      744010      RCL
00224      040470      DAC     BITCON     /SETUP FOR NEXT BIT
00225      740200      SZA
00226      600221      JMP     TEST+4     /TEST NEXT BIT POSITION
00227      600374      JMP     BURST
00230      777774      COMP    LAW      -4
00231      260457      XOR*   NXTPAT      /CHECK FOR LAST PATTERN
00232      540465      SAD     CNTRL
00233      620215      JMP*   TEST      /DID COMPLEMENT
00234      040465      DAC     CNTRL
00235      600216      JMP     TEST+1     /WRITE COMPLEMENT
/
      /GENERATE PATTERN
/
00236      000000      GENPAT  0
00237      200465      LAC     CNTRL      /CURRENT PATTERN WORD
00240      040472      DAC     SVMSTR     /SAVE
00241      200501      LAC     (1000
00242      040473      DAC     SVADR      /ADDRESS COUNTER
00243      771000      LAW     -7000
00244      040474      DAC     SVLTH
  
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00245 777714 LAR =70
00246 240466 DAC CT24 /COUNTS 4 X 16 SHIFTS
00247 200472 LAC SVMSTR /CURRENT CONTROL WORD
00251 440475 DAC PATR /SAVE
00251 777760 WCNT LAR =20
00252 240467 DAC CT16 /COUNTS 16 SHIFTS
00253 200475 LAC PATR /CONTROL WORD
00254 744010 RCL
00255 240475 DAC PATR
00256 751400 SZL:CLA
00257 740001 COMPL CMA /WRITE 777777
00260 240455 DAC PATWD
00261 200455 LAC PATWD
00262 620236 JMP* GENPAT /EXIT TO WRITE OR READ
/
00263 000000 WRITE 0
00264 100236 JMS GENPAT /GET A WORD
00265 060473 DAC* SVADR /WRITE
00266 100307 JMS CKXY /CHECK FOR PATTERN INVERSION
00267 620263 JMP* WRITE
/
/READ AND TEST
/
00270 000000 READ 0
00271 100236 JMS GENPAT /GET A WORD
00272 240477 DAC GOOD /SAVE
00273 200470 LAC BITCON
00274 260473 XOR* SVADR /COMPLEMENT A BIT
00275 060473 DAC* SVADR /WRITE WITH INVERTED BIT
00276 200470 LAC BITCON
00277 260473 XOR* SVADR /RE-COMPLEMENT
00300 060473 DAC* SVADR /RESTORE
00301 220473 LAC* SVADR /READ
00302 540477 SAD GOOD /COMPARE
00303 741000 SKP /O.K.
00304 600343 JMP ERROR /ERROR PATH
00305 100307 RTN JMS CKXY /CHECK FOR PATTERN INVERSION
00306 620270 JMP* READ /EXIT
/
/ROUTINE TO CHECK FOR PATTERN INVERSION
/
00307 000000 CKXY 0
00310 440474 ISZ SVLTH /DONE 4K IF SKIP
00311 741000 SKP
00312 620307 JMP* CKXY /EXIT TO WRITE OR READ
00313 440466 ISZ CT04 /DONE WITH Y AXIS IF SKIP
00314 741000 SKP
00315 600324 JMP Y64 /DONE 64 Y LINES
00316 200473 LAC SVADR
00317 340500 V64 TAD K120 /INCREMENT Y ADDRESS BY 1
00320 240473 DAC SVADR
00321 440467 ISZ CT16 /CHECK FOR 16 LOCATIONS
00322 600253 JMP WCNT+2 /NOT YET
00323 600247 JMP WCNT /RESTORE COUNT
/

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00420 440473 ISZ SVADR
00421 200502 LAC (1000)
00422 540473 SAD SVADR /DONE IF EQUAL
00423 741000 SKP
00424 600376 JMP WONS
00425 200501 LAC (1000)
00426 240473 DAC SVADR /1000 IS STARTING ADDR
00427 340500 TAD K100
00410 040475 BRSTA DAC PATR /SAVES XY COORDINATE
00411 200475 LAC PATR
00412 040474 DAC SVLTH /Y LINE ADDRESS
00413 776000 LAW -2000 /-512 DECIMAL
00414 240455 DAC PATWD
00415 160473 DZM* SVADR /CLEAR LINE XN
00416 220473 LAC* SVADR /READ 000000
00417 440455 ISZ PATWD /DISTURB LINE 512 TIMES
00420 600416 JMP .-2
00421 777777 BUST LAW -1
00422 260474 XOR* SVLTH /DATA MUST BE 777777
00423 741200 SNA /SHOULD NOT SKIP
00424 600430 JMP CEND /OK
00425 740001 CMA
00426 040476 DAC BAD
00427 600446 JMP -E5-1 /ERROR PATH
00430 200500 CEND LAC K100
00431 340474 TAD SVLTH /Y AXIS PLUS 1
00432 040474 DAC SVLTH
00433 200502 LAC (1000)
00434 500474 AND SVLTH
00435 540502 SAD (1000) /DONE ALL Y FOR CURRENT X
00436 741000 SKP /IF EQUAL
00437 600421 JMP BUST /READ NEXT Y ON CURRENT X
00440 440473 ISZ SVADR /INCREMENT X ADDRESS
00441 440475 ISZ PATR /INCREMENT X+Y ADDRESS
00442 200503 LAC (1100)
00443 540473 SAD SVADR /DONE 63 X LINES IF EQUAL
00444 600230 JMP COMP /WRITE NEXT CHECKERBOARD
00445 600411 JMP BRSTA /TEST NEXT X WITH Y02
/THRU Y63
/
00446 200474 /
00447 740040 E5 LAC SVLTH
00450 200476 LAC HLT /AC = FAILING X + Y63 LINE
00451 740040 E6 HLT BAD
00452 600430 JMP CEND /AC = BAD DATA
/READ ANOTHER
/
/CONSTANTS AND STORAGE REGISTERS
/
00453 777777 BITSUP LAW -1
00454 200000 PATCNT 0
00455 200000 PATWD 0
00456 200460 PATN .+2
00457 200460 NXTPAT .+1
00460 463144
00461 631460 631460

```

00462	525250		525250	
00463	000040	K40	40	
00464	000077	K77	77	
00465	000000	CNTRL	0	
00466	000000	CT04	0	
00467	000000	CT16	0	
00470	000000	BITCON	0	
00471	000001	K1	1	
00472	000000	SYMSTR	0	
00473	000000	SVAOR	0	
00474	000000	SVLTH	0	
00475	000000	PATR	0	
00476	000000	BAD	0	
00477	000000	GOOD	0	
00500	000100	K100	100	
	/			
00001			.LOC	1
00001	600001		JMP	1
00002	777777		LAW	-1
00003	777777		LAW	-1
00004	777777		LAW	-1
00005	777777		LAW	-1
	000000		.END	
00501	001000	*L		
00502	010000	*L		
00503	001100	*L		

NO ERROR LINES

.TITLE CKH115

```

/
/PDP-15 BASIC 4K MEMORY CHECKERBOARD
/SA = 7400, (RESIDES IN HIGH - TESTS LOW)
/
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/MAYNARD, MASS.
/
/J. RICHARDSON
/

```

.ABS

```

00001          .LOC 1
/
00001 600001    JMP      1
00002 777777    LAW      -1
00003 777777    LAW      -1
00004 777777    LAW      -1
00005 777777    LAW      -1
/
00200          .LOC 200
/
00200 607400    JMP      BEGIN
/
07400          .LOC 7400
/
07400 777777    BEGIN    LAW      -1
07401 047657    DAC      BITSUP
07402 777775    LAW      -3
07403 047660    DAC      PATCNT      /CONTROL WORD COUNT
07404 207667    LAC      PATN        /CONTROL WORD POINTER
07405 047670    DAC      NXTPAT
/
07406 227670    CKLP     LAC*     NXTPAT      /GET A CONTROL WORD
07407 047662    DAC      CNTRL     /SAVE
07410 107415    JMS      TEST     /WRITE PATTERN AND TEST
07411 447670    ISZ     NXTPAT    /INCREMENT POINTER
07412 447660    ISZ     PATCNT    /DONE BOTH IF SKIP
07413 607406    JMP      CKLP     /DO NEXT PATTERN
07414 607402    JMP      BEGIN+2  /START OVER
/
07415 000000    TEST     0
07416 107462    JMS      WRITE    /WRITE THE PATTERN
07417 207655    LAC      K1
07420 047663    DAC      BITCON   /USED TO COMPLEMENT BITS
07421 107467    JMS      READ     /READ AND TEST
07422 207663    LAC      BITCON
07423 744010    RCL
07424 247663    DAC      BITCON   /SETUP FOR NEXT BIT
07425 740200    SZA
07426 607421    JMP      TEST+4      /TEST NEXT BIT POSITION
07427 607571    JMP      BURST      /TEST ALL X LINES WITH
/
07430 777774    COMP     LAW      -4      /Y LINE #61,
07431 267670    XOR*    NXTPAT    /CHECK FOR LAST PATTERN
07432 547662    SAD      CNTRL

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07433	627415		JMP*	TEST	/HAVE DONE COMPLEMENT
07434	247662		DAC	CNTRL	
07435	607416		JMP	TEST+1	/WRITE COMPLEMENT
	/				
	/GENERATE PATTERN				
	/				
07436	000000	GENPAT	0		
07437	207662		LAC	CNTRL	/CURRENT CONTROL WORD
07440	247664		DAC	SVMSTR	/SAVE
07441	147665		DZM	SVADR	/ADDRESS COUNTER
07442	770400		LAW	=7400	
07443	247666		DAC	SVLTH	
07444	777704		LAW	-74	
07445	047650		DAC	CT04	/COUNTS Y LINES
07446	207664		LAC	SVMSTR	/CURRENT CONTROL WORD
07447	047652		DAC	PATR	/SAVE
07450	777760	WCNT	LAW	=20	
07451	047651		DAC	CT16	/COUNTS 16 SHIFTS
07452	207652		LAC	PATR	/CONTROL WORD
07453	744010		RCL		
07454	047652		DAC	PATR	
07455	751400		SZL:CLA		
07456	740001	COMPL	CMA		/WRITE 777777
07457	047661		DAC	PATWD	
07460	207661		LAC	PATWD	
07461	627436		JMP*	GENPAT	/EXIT TO WRITE OR READ
	/				
07462	000000	WRITE	0		
07463	107436		JMS	GENPAT	/GET A WORD
07464	067665		DAC*	SVADR	/WRITE
07465	107506		JMS	CKXY	/CHECK FOR PATTERN INVERSION
07466	627462		JMP*	WRITE	/DONE 7500 IF SKIP
	/				
	/READ AND TEST				
	/				
07467	000000	READ	0		
07470	107436		JMS	GENPAT	/GET A WORD
07471	047654		DAC	GOOD	/SAVE
07472	207663		LAC	BITCON	
07473	267665		XOR*	SVADR	/COMPLEMENT A BIT
07474	067665		DAC*	SVADR	/WRITE WITH INVERTED BIT
07475	207663		LAC	BITCON	
07476	267665		XOR*	SVADR	/RE-COMPLEMENT
07477	067665		DAC*	SVADR	/RESTORE
07500	227665		LAC*	SVADR	/READ
07501	547654		SAD	GOOD	/COMPARE
07502	741000		SKP		/OK
07503	607540		JMP	ERROR	/ERROR PATH
07504	107506	RTN	JMS	CKXY	/CHECK FOR PATTERN INVERSION
07505	627467		JMP*	READ	/EXIT
	/				
	/ROUTINE TO CHECK FOR PATTERN INVERSION				
	/				
07506	000000	CKXY	0		
07507	447666		ISZ	SVLTH	/DONE 4K IF SKIP

07510	741000		SKP		
07511	627506		JMP*	CKXY	/EXIT TO WRITE OR READ
07512	447650		ISZ	CT04	/DONE WITH Y AXIS IF SKIP
07513	741000		SKP		
07514	607523		JMP	Y64	/DONE 64 Y LINES
07515	207665		LAC	SVADR	
07516	347656	N64	TAD	K100	/INCREMENT Y ADDRESS BY 1
07517	047665		DAC	SVADR	
07520	447651		ISZ	CT16	/CHECK FOR 16 LOCATIONS
07521	607452		JMP	WCNT+2	/NOT YET
07522	607446		JMP	WCNT=2	/RESTORE COUNT
	/				
07523	447665	Y64	ISZ	SVADR	/INCREMENT X LINE BY 1
07524	777704		LAW	=74	
07525	047650		DAC	CT04	/RESTORE Y LINE COUNTER
07526	207665		LAC	SVADR	
07527	507647		AND	K77	
07530	047665		DAC	SVADR	
07531	547646		SAD	K40	/COMPLEMENT PATTERN IF EQUAL
07532	741000		SKP		
07533	607520		JMP	N64+2	/START WITH NEW X-Y COMBO
07534	207664		LAC	SVMSTR	/PATTERN CONTROL WORD
07535	740001		CMA		
07536	047664		DAC	SVMSTR	/COMPLEMENTED CONTROL WORD
07537	607520		JMP	N64+2	
	/				
	/				
07540	047653	ERROR	DAC	BAD	/SAVE
07541	741200		SNA		/CHECK FOR FULL WORD ERROR
07542	607555		JMP	E1-1	/FULL WORD ERROR
07543	740001		CMA		
07544	741200		SNA		
07545	607555		JMP	E1-1	/FULL WORD ERROR
07546	207653		LAC	BAD	
07547	507657		AND	BITSUP	/SEE IF BIT SUPPRESSED
07550	740200		SZA		
07551	740001		CMA		
07552	507657		AND	BITSUP	
07553	741200		SNA		
07554	607504		JMP	RTN	/BIT SUPPRESSED
	/				
07555	207665		LAC	SVADR	
07556	740040	E1	HLT		/AC = FAILING ADDRESS
07557	207653		LAC	BAD	
07560	740040	E2	HLT		/AC = BAD DATA
07561	207654		LAC	GOOD	
07562	740040	E3	HLT		/AC = GOOD DATA
07563	207662		LAC	CNTRL	
07564	740040	E4	HLT		/AC = PATTERN CONTROL WORD
07565	750004		LAS		/SUPPRESSED BITS
07566	740001		CMA		
07567	047657		DAC	BITSUP	
07570	607504		JMP	RTN	/READ ANOTHER

/

/READ AND TEST Y LINES 01 TO 49 WITH X

/LINES 00 THRU 63, EACH X LINE WILL EQUAL
 /000000. AN X LINE WILL BE READ 1024 TIMES
 /AFTER WHICH, ALL Y LINES INTERSECTING,
 /WITH THAT X LINE WILL BE READ AND TESTED
 /FOR BIT ERRORS.

/					
07571	147665	BURST	DZM	SVADR	
07572	777777	WONS	LAW	-1	
07573	067665		DAC*	SVADR	/WRITE 1'S IN 0000 TO 7400
07574	447665		ISZ	SVADR	
07575	207674		LAC	(7400	
07576	547665		SAD	SVADR	/DONE IF 7400
07577	741000		SKP		
07600	607572		JMP	WONS	
07601	147665		DZM	SVADR	/0000 IS STARTING ADDRESS
07602	207656		LAC	K100	
07603	047652		DAC	PATR	/SAVES XY COORDINATE
07604	207652	BRSTA	LAC	PATR	
07605	047666		DAC	SVLTH	/Y LINE ADDRESS
07606	776000		LAW	-2000	/=1024 DECIMAL
07607	047661		DAC	PATWD	
07610	167665		DZM*	SVADR	/CLEAR LINE XN
07611	227665		LAC*	SVADR	/READ 000000
07612	447661		ISZ	PATWD	/DISTURB LINE 1024 TIMES
07613	607611		JMP	2	
07614	777777	BUST	LAW	-1	
07615	267666		XOR*	SVLTH	/DATA MUST BE 777777
07616	741200		SNA		/SHOULD NOT SKIP
07617	607623		JMP	CEND	/OK
07620	740001		CMA		
07621	047653		DAC	BAD	
07622	607641		JMP	E5-1	/ERROR PATH
07623	207656	CEND	LAC	K100	
07624	347666		TAD	SVLTH	/Y AXIS PLUS 1
07625	047666		DAC	SVLTH	
07626	207674		LAC	(7400	
07627	507666		AND	SVLTH	
07630	547674		SAD	(7400	/DONE ALL Y ON CURRENT X LINE
07631	741000		SKP		/IF EQUAL
07632	607614		JMP	BUST	/READ NEXT Y ON CURRENT X
07633	447665		ISZ	SVADR	/INCREMENT X ADDRESS
07634	447652		ISZ	PATR	/INCREMENT X+Y ADDRESS
07635	207656		LAC	K100	
07636	547665		SAD	SVADR	/DONE 64 X LINES IF EQUAL
07637	607430		JMP	COMP	/WRITE NEXT CHECKERBOARD
07640	607604		JMP	BRSTA	/TEST NEXT X WITH Y01 THRU Y60
/					
07641	207666		LAC	SVLTH	
07642	740040	E5	HLT		/AC = FAILING X + Y61 LINE
07643	207653		LAC	BAD	
07644	740040	E6	HLT		/AC = BAD DATA
07645	607623		JMP	CEND	

/CONSTANT AND STORAGE REGISTERS

```
07646 000040 / K40 40
07647 000077 K77 77
07650 000000 CT04 0
07651 000000 CT16 0
07652 000000 PATR 0
07653 000000 BAD 0
07654 000000 GOOD 0
07655 000001 K1 1
07656 000100 K100 100
07657 777777 BITSUP LAW -1
07660 000000 PATCNT 0
07661 000000 PATWD 0
07662 000000 CNTRL 0
07663 000000 BITCON 0
07664 000000 SVMSTR 0
07665 000000 SVADR 0
07666 000000 SVLTH 0
07667 007671 PATN .+2
07670 007671 NXPAT .+1
07671 463144 463144
07672 631460 631460
07673 525250 525250
/
07674 000000 .END
007400 *L
NO ERROR LINES
```