

IDENTIFICATION

Product Code: MAINDEC 08-D02B-D
Product Name: PDP-8 Instruction Test Part 2B
Date Created: January 12, 1968
Maintainer: Diagnostic Group

1. ABSTRACT

This program is a test of the 2s complement add (TAD) and rotate logic (RAL, RTL, RAR, RTR). Random numbers are used in the Twos Add portion of the test and sequential numbers are used in the Rotate portion. Program control depends on operator manipulation of four switches in the SWITCH REGISTER (bits 0, 1, 2, 3). Error information is normally printed out on the keyboard printer.

2. REQUIREMENTS

Storage

Memory locations 20_8-4177_8 .

Subprograms and/or Subroutines

High RIM Loader, High Binary Loader.

Equipment

PDP-8 Processor-Keyboard Reader

3. USAGE

3.1 Loading

If the Binary Loader beginning at 7777_8 is in memory, load the Instruction Test - Part 2b. Otherwise, the RIM Loader beginning at 7756_8 and/or the Binary Loader must be loaded into memory.

PDP-8 Instruction Test - Part 2B (Maindec 801-2B) may now be loaded as follows:

Set 7777_8 in the SWITCH REGISTER.

Press LOAD ADDRESS key.

Place Instruction Test-Part 2B in the keyboard reader.

Press START key on the operator console.

Engage the keyboard reader.

3.2 Switch Settings

When starting at the TAD portion (200_8) of the test, set switches 0 and 2 to the 1 state. This switch configuration allows the program to print any error message and halt on the error condition. After the TAD portion has run for a minimum of 10 minutes, set switch 3 to a 1 to enter the Rotate Test.

When starting at the rotate portion (2000_8) set switches 0 and 2 to the 1 state as above. This switch configuration allows the program to print any error message and halt on the error condition.

Switch 0	Stop on error (406_8 for TAD or 2433_8 for Rotate Test).
Switch 1	Scope mode (repeat loop causing the error).
Switch 2	Print error.
Switch 3	Leave the Twos Add test and start the Rotate Test.

- Switch 0 and 1 Scope mode and stop on error.
- Switch 0 and 2 Print error and halt.
- Switch 1 and 2 Scope and print error.

3.3 Start-Up and/or Entry

The starting address of the TAD portion of the test is 0200_g. The starting address of the Rotate portion of the test is 2000_g. If bit 3 of the SWITCH REGISTER is set, it automatically causes an exit from the Twos Add portion of the test to the Rotate portion of the test.

Set either 0200_g in the SWITCH REGISTER to start at the Twos Add portion of the test, or set 2000_g in the SWITCH REGISTER to start at the Rotate portion of the test.

Press the LOAD ADDRESS key.

Press the START key.

3.4 Errors in Usage

The error halt for TAD Test is 406_g.

The error halt for Rotate Test is 2433_g.

Error printouts from both tests would appear as follows:

TWOS ADD ERROR PRINTOUT:

Good	Bad	X ARG	Y ARG
0 000000000001	0 000000000000	0 000000000000	000000000001

Indicating loss of a 1 bit in AC bit 11.

ROTATE ERROR PRINTOUTS:

PAT 0	000000000001	(original pattern)
RAL 0	000000000010	(pattern after RAL inst.)
RAR 0	000000000000	(pattern after RAR inst.)

Indicating loss of a 1 bit in AC bit 11 as a result of an RAR.

PAT 0	000000100000
RTR 0	000000000000
RTL 0	000000000000

Indicating loss of a 1 bit in AC bit 8 as a result of an RTR.

3.5 Recovery from such Errors

The program may be continued after it halts on an error, by pressing the CONTINUE key. The program continues to the next test, unless scope mode (bit 1) is requested.

Set the state of AC switch 1 to 1 to repeat the loop causing the error (scope mode).

Reference 4.3 for other switch variations.

4. RESTRICTIONS

This test should be run only after a successful run of the Instruction Test 2A to provide maximum reliability of the module repair table.

5. DESCRIPTION

5.1 Discussion

The PDP-8 Instruction Test-Part 2B tests the 2s ADD and ROTATE logic.

The 2s ADD logic is tested by the addition of pseudo random numbers. Two pseudo random numbers are generated and 2s added by a logical (simulated) adder. The same two numbers are added by the 2s add logic (TAD). The results are compared, and if an equality exists, two new random numbers are generated and the sequence is re-executed. If an inequality exists, the computer halts and/or types the error condition depending on the switch settings.

5.2 Examples and/or Applications

The error printout will contain the correct answer, the incorrect answer, and the two random numbers used.

Visual inspection of these patterns will determine the cause of the error. A lookup table is provided for rapid repair which will give all of the information shown in section 4.6.

Exit from TAD Test to the Rotate portion is accomplished by setting bit 3 in the SWITCH REGISTER. This switch also causes the program to print "ADD OK."

The Rotate Test generates 8192 patterns to be tested on two pairs of rotate instructions. The first pair of rotate instructions to be tested is RAL and RAR. The test pattern is rotated left once, then the result is rotated right once. The following items are compared:

The result of the RAR should equal the test pattern and original link.

The result of the link after the RAL should equal bit 0 of the test pattern.

If the RAR results and link equals the test pattern and link, the RAL and RAR instructions have operated correctly.

If an error occurs and an error printout is requested, the test pattern and the results of both the RAL and RAR instructions are printed. Visual inspection of these patterns will determine the probable cause of the error.

The second pair of rotate instructions to be tested is RTR and RTL. The test pattern is rotated right twice, then the result is rotated left twice. The following items are compared:

The result of the RTL should equal the test pattern and original link.

The result of the link after the RTR should equal pattern bit 1 of the test pattern.

If the RTL results and link equal the test pattern and link, the RTR and RTL, instructions have operated correctly.

If an error occurs and an error printout is requested, the test pattern and the results of both the RTR and RTL instructions are printed. Visual inspection of these patterns will determine the probable cause of the error.

After a complete pass through the Rotate Test, the computer will print ROT.

A printout of "2B" indicates the completion of a complete pass through the entire set of tests, after which the test begins again.

6. METHODS

See description section 5.

7. EXECUTION TIME

The TAD section takes 1 second for one complete pass; it will cycle continuously unless AC switch 3 is set. The Rotate portion takes 3 seconds for one complete pass.

8. PROGRAM LISTING

1/11/68 3:19,9

```
/PDP-8 INSTRUCTION TEST PART 2B ADD=ROTATE
*0
0000 0000
0001 5001
0002 0002
0003 0003

*0020
0020 0000 PRXLOP, 0 /PRINT LOOP
0021 6046 TLS
0022 6041 LPXX, TSF
0023 5022 JMP LPXX
0024 7200 CLA
0025 5420 JMP I PRXLOP

0026 0000 CRLF, 0
0027 7240 CLA CMA
0030 0104 AND CR /CR
0031 4020 JMS PRXLOP
0032 7240 CLA CMA
0033 0103 AND LF /LF
0034 4020 JMS PRXLOP
0035 7240 CLA CMA
0036 0103 AND LF /LF
0037 4020 JMS PRXLOP
0040 5426 JMP I CRLF

0041 0000 CRLF, 0
0042 7240 CLA CMA
0043 0104 AND CR /CR
0044 4020 JMS PRXLOP
0045 7240 CLA CMA
0046 0103 AND LF /LF
0047 4020 JMS PRXLOP
0050 5441 JMP I CRLF

0051 0000 PAT, 0 /GENERATOR PATTERN
0052 0000 RALRTL, 0 /ROTATE LEFT PATTERNS
0053 0000 LFTLNK, 0 /ROTATE LEFT LINK PATTERNS
0054 0000 RARRTH, 0 /ROTATE RIGHT PATTERNS
0055 0000 RJTLNK, 0 /ROTATE RIGHT LINK PATTERNS
0056 0000 TST1, 0 /TEST FLAG
```

1/11/68 3:19,13

0057	0000	PROUT,	0	/PRINT OUT LOCATION
0060	4000	K4000,	4000	/MASK LIST
0061	2000	K2000,	2000	
0062	1000	K1000,	1000	
0063	0400	K0400,	0400	
0064	0200	K0200,	0200	
0065	0100	K0100,	0100	
0066	0040	K0040,	0040	
0067	0020	K0020,	0020	
0070	0010	K0010,	0010	
0071	0004	K0004,	0004	
0072	0002	K0002,	0002	
0073	0001	K0001,	0001	
0074	0057	XPROUT,	PROUT	
0075	0322	R,	0322	/R
0076	0301	A,	0301	/A
0077	0314	L,	0314	/L
0100	0324	T,	0324	/T
0101	0320	P,	0320	/P
0102	0240	SP,	0240	/SP
0103	0212	LF,	0212	/LF
0104	0215	GR,	0215	/GR
0105	0060	ZERO,	0060	/ZERO
0106	0061	ONE,	0061	/ONE
0107	0317	O,	0317	/O ALPHA
0110	0313	K,	0313	/K
0111	7764	COUNT,	7764	/MINUS 11
0112	0000	STRCNT,	0	
0113	0262	TWO,	0262	/2
0114	0302	B,	0302	/B
0115	0000	WD1,	0	
0116	0000	WD2,	0	
0117	0000	BW1,	0	
0120	0000	CRY,	0	
0121	0000	TOTAL,	0	
0122	0000	SUM,	0	
0123	0000	CNTR,	0	
0124	0000	HEADEN,	0	
0125	0000	BITSTR,	0	
0126	7776	SPAC00,	7776	/MINUS 1
0127	0000	SPACST,	0	
0130	0307	G,	0307	/G
0131	0304	U,	0304	/U
0132	0330	X,	0330	/X
0133	0331	Y,	0331	/Y
0134	0000	LINK,	0	/LINK
0135	0000	XARG,	0	/XARG
0136	0000	YARG,	0	/YARG
0137	7763	COUNTX,	7763	
0140	0000	LNKSTR,	0	
0141	7377	K7377,	7377	

0357 1125
0360 5741

TAD TW6
JMP I SLOC

```
39<2 0000 0
0143 7240   CLA CMA
0144 0140   AND Z LNKSTR
0145 7440   SZA
0146 5150   JMP SL
0147 5152   JMP CL
0150 7360 SL,   CLA CMA STL
0151 5542   JMP I CX
0152 7340 CL,  CLL CLA CMA
0153 5542   JMP I CX
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```

*4000
4000 7200 RAND2,      CLA
4001 1417   TAD I 0017
4002 3135   DCA XARG           /STORE FIXED PAT
4003 1417   TAD I 0017
4004 3136   DCA YARG           /STORE FIXED PAT
4005 2216   ISZ RCNT
4006 5647   JMP I XSTRXY       /EXIT TO TEST
4007 1215   TAD LISTX
4010 3017   DCA 0017
4011 1214   TAD M144
4012 3216   DCA RCNT
4013 5647   JMP I XSTRXY       /EXIT TO TEST

4014 7634   M144,      -144
4015 4177   LISTX,    LIST-1
4016 0000   RCNT,     0000
4017 0000   ODEVEN,   0000

4020 7300   RAND,      CLL CLA           /FIXED PATTERN
4021 2217   ISZ ODEVEN           /RANDOM PATTERN
4022 7000   NOP
4023 1217   TAD ODEVEN
4024 7010   RAR
4025 7630   SZL CLA
4026 5230   JMP RAND1
4027 5200   JMP RAND2

4030 7604   RAND1,    CLA OSR
4031 0063   AND Z K0400
4032 7000   NOP
4033 7440   SZA
4034 5650   JMP I ADDX           /SW 3 EQUALS A ONE TO EXIT
4035 7240   CLA CMA
4036 0121   AND Z TOTAL
4037 7000   NOP
4040 3135   DCA Z XARG
4041 7040   CMA
4042 0121   AND Z TOTAL
4043 7001   IAC
4044 1410   TAD I Z 10
4045 3136   DCA Z YARG
4046 5647   JMP I XSTRXY
4047 0225   XSTRXY,    STRXY
4050 0312   ADDX,     PAADOK

```

```

*0017
0017 4177 LIST-1

*4051
4051 7240 FCOMP,      CLA CMA      /COMPARE SUM AND TOTAL
4052 0121   AND Z TOTAL
4053 7040   CMA
4054 0122   AND Z SUM
4055 3275   DCA CXM
4056 7240   CLA CMA
4057 0122   AND Z SUM
4060 7040   CMA
4061 0121   AND Z TOTAL
4062 3274   DCA CXN
4063 7240   CLA CMA
4064 0275   AND CXM
4065 7440   SZA
4066 5676   JMP I ERX      /ERROR
4067 7240   CLA CMA
4070 0274   AND CXN
4071 7440   SZA
4072 5676   JMP I ERX      /ERROR
4073 5277   JMP LCOMP
4074 0000   CXN,          0
4075 0000   CXM,          0
4076 0400   ERX,         ERROR
4077 7240   LCOMP,      CLA CMA      /COMPARE CRY AND LINK
4100 0134   AND Z LINK      /LINK BIT IN BIT 11
4101 7040   CMA
4102 0120   AND Z CRY
4103 3322   DCA LRX
4104 7240   CLA CMA
4105 0120   AND Z CRY
4106 7040   CMA
4107 0134   AND Z LINK
4110 3323   DCA LRY
4111 7240   CLA CMA
4112 0322   AND LRX
4113 7440   SZA
4114 5676   JMP I ERX      /ERROR
4115 7240   CLA CMA
4116 0323   AND LRY
4117 7440   SZA
4120 5676   JMP I ERX      /ERROR
4121 5724   JMP I NOERX
4122 0000   LRX,          0
4123 0000   LRY,          0
4124 0407   NOERX,       NOERR

```

*4200

4200	7777	LIST,	7777	4262	7777	7777
4201	7777	7777		4263	0001	0001
4202	7776	7776		4264	7777	7777
4203	7777	7777		4265	0002	0002
4204	7775	7775		4266	7777	7777
4205	7777	7777		4267	0004	0004
4206	7773	7773		4270	7777	7777
4207	7777	7777		4271	0010	0010
4210	7767	7767		4272	7777	7777
4211	7777	7777		4273	0020	0020
4212	7757	7757		4274	7777	7777
4213	7777	7777		4275	0040	0040
4214	7737	7737		4276	7777	7777
4215	7777	7777		4277	0100	0100
4216	7677	7677		4300	7777	7777
4217	7777	7777		4301	0200	0200
4220	7577	7577		4302	7777	7777
4221	7777	7777		4303	0400	0400
4222	7377	7377		4304	7777	7777
4223	7777	7777		4305	1000	1000
4224	6777	6777		4306	7777	7777
4225	7777	7777		4307	2000	2000
4226	5777	5777		4310	7777	7777
4227	7777	7777		4311	4000	4000
4230	3777	3777		4312	0001	0001
4231	7777	7777		4313	7777	7777
4232	7777	7777		4314	0002	0002
4233	7777	7777		4315	7777	7777
4234	7776	7776		4316	0004	0004
4235	7777	7777		4317	7777	7777
4236	7775	7775		4320	0010	0010
4237	7777	7777		4321	7777	7777
4240	7773	7773		4322	0200	0200
4241	7777	7777		4323	7777	7777
4242	7767	7767		4324	0400	0400
4243	7777	7777		4325	7777	7777
4244	7757	7757		4326	0100	0100
4245	7777	7777		4327	7777	7777
4246	7737	7737		4330	0200	0200
4247	7777	7777		4331	7777	7777
4250	7677	7677		4332	0400	0400
4251	7777	7777		4333	7777	7777
4252	7577	7577		4334	1000	1000
4253	7777	7777		4335	7777	7777
4254	7377	7377		4336	2000	2000
4255	6777	6777		4337	7777	7777
4256	7777	7777		4340	4000	4000
4257	5777	5777		4341	7777	7777
4260	7777	7777				
4261	3777	3777				

```

*0200
0200 7240 ARITH,      CLA CMA
0201 3124 DCA Z HEADER
0202 7240 CLA CMA
0203 3135 DCA XARG
0204 7240 CLA CMA
0205 3136 DCA YARG
0206 7240 CLA CMA
0207 3121 DCA TOTAL
0210 3134 DCA Z LINK
0211 3115 DCA Z WD1
0212 5223 JMP INCR
0213 3120 DCA Z CRY

0214 7340 ADD,      CLA CMA CLL
0215 0135 AND Z XARG
0216 1136 TAD Z YARG
0217 3122 DCA Z SUM          /STORE SUM OF REAL ADD
0220 7004 RAL
0221 3134 DCA Z LINK          /STORE LINK OF REAL ADD AT BIT 11
0222 5737 JMP I XFCOMP        /COMPARE SUM AND TOTAL

0223 5624 INCR,      JMP I INCRX
0224 4020 INCRX,     RAND

0225 7240 STRXY,     CLA CMA
0226 0135 AND Z XARG
0227 3115 DCA Z WD1          /XARG EQUALS WD2
0230 7240 CLA CMA
0231 0136 AND Z YARG
0232 3116 DCA Z WD2          /YARG EQUALS WD2
0233 4235 JMS ADDISM        /JMS TO FAKE ADD
0234 5214 JMP ADD

```

0235	0000	ADDISM,	0		/FAKE ADD
0236	7300	CLA	CLL		
0237	3121	DCA	Z TOTAL		
0240	3120	DCA	Z CRY		
0241	7040	CMA			
0242	0111	AND	Z COUNT		/MINUS 11
0243	3123	DCA	Z CNTR		
0244	7040	AXISM,		CMA	
0245	0115	AND	Z WD1		
0246	7010	RAR			
0247	3115	DCA	Z WD1		
0250	7004	RAL			
0251	3117	DCA	Z BW1		
0252	7040	CMA			
0253	0116	AND	Z WD2		
0254	7010	RAR			
0255	3116	DCA	Z WD2		
0256	7040	CMA			
0257	0117	AND	BW1		
0260	7420	SNL			
0261	5302	JMP	DISM		
0262	7450	SNA			
0263	5305	JMP	CISM		
0264	7300	CLL	CLA		
0265	7040	AXISM,		CMA	
0266	0120	AND	Z CRY		
0267	7010	RAR			
0270	7040	CMA			
0271	0117	AND	Z BW1		
0272	3120	BISM,		DCA Z CRY	
0273	7040	CMA			
0274	0121	AND	Z TOTAL		
0275	7010	RAR			
0276	3121	DCA	Z TOTAL		
0277	2123	ISZ	Z CNTR		
0300	5244	JMP	AXISM		
0301	5635	JMP	I ADDISM		
0302	7450	DISM,		SNA	
0303	5265	JMP	AXISM		
0304	7220	CML	CLA		
0305	7040	CISM,		CMA	
0306	0120	AND	Z CRY		
0307	7440	SZA			
0310	7100	CLL			
0311	5272	JMP	BISM		

0312	4041	PADDOK,	JMS Z CRLF	/CR LF
0313	7240	CLA CMA		
0314	0076	AND Z A		/A
0315	4020	JMS Z PRXLOP		
0316	7240	CLA CMA		
0317	0131	AND Z D		/D
0320	4020	JMS Z PRXLOP		
0321	7240	CLA CMA		
0322	0131	AND Z D		/D
0323	4020	JMS Z PRXLOP		
0324	7240	CLA CMA		
0325	0102	AND Z SP		/SP
0326	4020	JMS Z PRXLOP		
0327	7240	CLA CMA		
0330	0107	AND Z O		/O
0331	4020	JMS Z PRXLOP		
0332	7240	CLA CMA		
0333	0110	AND Z K		/K
0334	4020	JMS Z PRXLOP		
0335	5736	JMP I ROTATE		/EXIT ADD TEST
0336	2000	ROTATE,	GEN1	
0337	4051	XFCOMP,	FCOMP	

```

*0400
0400 7604 ERROR,      CLA OSR          /READ IN SR
0401 7106  CLL RTL
0402 7510  SPA          /SW2 EQUALS A ONE TO PRINT
0403 4216  JMS PRINT    /JMS TO PRINT ROUTINE
0404 7604  CLA OSR
0405 7510  SPA          /SW0 EQUALS A ONE TO HALT
0406 7402  HLT          /HALT ON ERROR
0407 7604 NOERR,      CLA OSR
0410 7104  CLL RAL
0411 7510  SPA          /SW1 EQUALS A ONE TO SCOPE MODE
0412 5614  JMP I SXY    /SCOPE MODE
0413 5615  JMP I INCR   /CONTINUE MODE
0414 0225  SXY,        STRXY
0415 0223  INCR,      INCR

0416 0000  PRINT,      0
0417 7240  CLA CMA
0420 0124  AND Z HEADER /HEADER FLAG
0421 7440  SZA
0422 4321  JMS PRHEAD   /JMS TO PRINT HEADER ROUTINE
0423 7000  PRERR,      NOP
0424 4041  JMS Z CRLF   /CR LF
0425 4020  JMS Z PRXLOP
0426 7240  CLA CMA
0427 0120  AND Z CRY
0430 4635  JMS I XONZER /TEST FAKE LINK FOR SEX AND
/PRINT A ONE OR ZERO

0431 7240  CLA CMA
0432 0102  AND Z SP     /PRINT SP
0433 4020  JMS Z PRXLOP
0434 5236  JMP PTOTAL   /PRINT CONTENTS OF FAKE ADD
0435 2637  XONZER,     ONZER

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0436 7240 PTOTAL,      CLA CMA
0437 0121  AND Z TOTAL      /STORE CONTENTS OF FAKE ADD
0440 3125  DCA Z BITSTR
0441 4266  JMS MESSG
0442 7240  CLA CMA
0443 0134  AND Z LINK      /TEST REAL LINK FOR SEX AND
0444 4635  JMS I XONZER     /PRINT A ONE OR ZERO

0445 7240  CLA CMA
0446 0102  AND Z SP        / PRINT SP
0447 4020  JMS Z PRXLOP
0450 5251  JMP XTOTAL

0451 7240 XTOTAL,      CLA CMA
0452 0122  AND Z SUM
0453 3125  DCA Z BITSTR     /STORE CONTENTS OF REAL ADD
0454 4266  JMS MESSG
0455 7240  CLA CMA
0456 0135  AND Z XARG
0457 3125  DCA Z BITSTR     /STORE XARG
0460 4266  JMS MESSG
0461 7240  CLA CMA
0462 0136  AND Z YARG
0463 3125  DCA Z BITSTR     /STORE Y ARG
0464 4266  JMS MESSG
0465 5616  JMP I PRINT     /EXIT TO SWITCH ROUTINE

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0466 0000 MESSG,      0
0467 7240   CLA CMA
0470 0137   AND Z COUNTX
0471 3112   DCA Z STRCNT
0472 2112   NBIT,      ISZ Z STRCNT
0473 7410   SKP
0474 5312   JMP PRSPAC           /12 COUNTS FINISHED
0475 7240   CLA CMA
0476 0125   AND Z BITSTR
0477 7100   CLL
0500 7004   RAL
0501 3125   DCA Z BITSTR       /STORE ROTATED WORD
0502 7430   SZL
0503 5306   JMP PRONE
0504 4764   PRZERO,      JMS I XZEROR       /PRINT ZERO
0505 5272   JMP NBIT
0506 7240   PRONE,      CLA CMA
0507 0106   AND Z ONE
0510 4020   JMS Z PRXLOP       /PRINT ONE
0511 5272   JMP NBIT
0512 7240   PRSPAC,     CLA CMA
0513 0102   AND Z SP
0514 4020   JMS Z PRXLOP       /SP
0515 7240   CLA CMA
0516 0102   AND Z SP           /SP
0517 4020   JMS Z PRXLOP
0520 5666   JMP I MESSG

0521 0000 PRHEAD,      0
0522 7200   CLA
0523 3124   DCA Z HEADER       /CLEAR HEADER FLAG
0524 7240   CLA CMA
0525 0126   AND Z SPAC06
0526 3127   DCA Z SPACST       /STORE SPACE COUNT
0527 4041   JMS Z CRLF         /PRINT CR LF

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0530	7240	SPA06,	CLA CMA	
0531	0102	AND Z SP		
0532	4020	JMS Z PRXLOP		/PRINT 6 SPACES
0533	2127	ISZ Z SPACST		
0534	5330	JMP SPA06		
0535	7240	CLA CMA		
0536	0130	AND Z G		/G
0537	4020	JMS Z PRXLOP		
0540	7240	CLA CMA		
0541	0107	AND Z O		/O ALPHA
0542	4020	JMS Z PRXLOP		
0543	7240	CLA CMA		
0544	0107	AND Z O		/O ALPHA
0545	4020	JMS Z PRXLOP		
0546	7240	CLA CMA		
0547	0131	AND Z D		/D
0550	4020	JMS Z PRXLOP		
0551	4762	JMS I MANYSP		/JMP TO PRINT 12 SPACES
0552	7240	CLA CMA		
0553	0114	AND Z B		/B
0554	4020	JMS Z PRXLOP		
0555	7240	CLA CMA		
0556	0076	AND Z A		/A
0557	4020	JMS Z PRXLOP		
0560	5761	JMP I CONHED		
0561	0600	CONHED,	HEDCON	
0562	0626	MANYSP,	TWELVE	
0563	5721	HEDRJ,	JMP I PRHEAD	/EXIT HEADER ROUTINE
0564	2702	XZEROR,	ZEROR	

```

*0600
0600 7240 HEDCON,      CLA CMA
0601 0131 AND Z D      /D
0602 4020 JMS Z PRXLOP
0603 4226 JMS TWELVE   /12 SPACES
0604 7240 CLA CMA
0605 0132 AND Z X      /X
0606 4020 JMS Z PRXLOP
0607 7240 CLA CMA
0610 0102 AND Z SP     /SP
0611 4020 JMS Z PRXLOP
0612 4240 JMS ARGXXX   /ARG
0613 4226 JMS TWELVE   /12 SPACES
0614 7240 CLA CMA
0615 0133 AND Z Y      /Y
0616 4020 JMS Z PRXLOP
0617 7240 CLA CMA
0620 0102 AND Z SP     /SP
0621 4020 JMS Z PRXLOP
0622 4240 JMS ARGXXX   /ARG
0623 4041 JMS Z CRLF   /CR LF
0624 5625 JMP I RJHED   /JUMP TO EXIT HEADER ROUTINE
0625 0563 RJHED,      HEDRJ
0626 0000 TWELVE,      0
0627 7240 CLA CMA
0630 0111 AND Z COUNT
0631 3127 DCA Z SPACST /STORE MINUS 12
0632 7240 SPA12,      CLA CMA
0633 0102 AND Z SP     /SP
0634 4020 JMS Z PRXLOP /PRINT 12 SPACES
0635 2127 ISZ Z SPACST
0636 5232 JMP SPA12
0637 5626 JMP I TWELVE

0640 0000 ARGXXX,      0
0641 7240 CLA CMA
0642 0076 AND Z A      /A
0643 4020 JMS Z PRXLOP
0644 7240 CLA CMA
0645 0075 AND Z R      /R
0646 4020 JMS Z PRXLOP
0647 7240 CLA CMA
0650 0130 AND Z G      /G
0651 4020 JMS Z PRXLOP
0652 5640 JMP I ARGXXX

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*2000
2000 4316 GEN1,          JMS HSEKP
2001 4142 CONT1,       JMS Z CX
2002 0051 AND Z PAT
2003 7001 IAC
2004 3051 DCA Z PAT          /STORE INCREMENTED PATTERN
2005 7420 SNL
2006 5215 JMP CLRLNK          /JMP TO CLEAR LNKSTR
2007 1060 TAD K4000
2010 3140 DCA Z LNKSTR      /SET LNKSTR TO 4000
2011 4352 PT1EX,        JMS EX
2012 7440 SZA
2013 5220 JMP ROT1
2014 5274 JMP GEN2          /EXIT ROT1
2015 7200 CLRLNK,       CLA
2016 3140 DCA Z LNKSTR
2017 5211 JMP PT1EX

2020 7240 ROT1,        CLA CMA
2021 3056 DCA Z TST1          /SET TST1 FLAG
2022 7340 CLL CLA CMA
2023 0140 AND Z LNKSTR
2024 7440 SZA
2025 5272 JMP SETLNK
2026 7140 CLL CMA          /CLEAR LINK
2027 0051 REROT1,      AND Z PAT          /BRING UP PATTERN
2030 7004 RAL
2031 3052 DCA Z RALRTL      /STORE RAL PATTERN
2032 7430 SZL              /SKIP IF LINK EQUALS A ZERO
2033 1060 TAD Z K4000      /SET RAL LINK STORE
2034 3053 DCA Z LFTLNK     /CLEAR RAL LINK STORE
2035 7240 CLA CMA
2036 0052 AND Z RALRTL
2037 7010 RAR
2040 3054 DCA Z RARRTR     /STORE RAR PATTERN
2041 7430 SZL              /SKIP IF LINK EQUALS A ZERO
2042 1060 TAD Z K4000      /SET RAR LINK STORE
2043 3055 DCA Z RITLNK     /CLEAR RAR LINK STORE

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2044	7340	CLL CLA CMA	
2045	0054	AND Z RARRTR	/RARRTR SHOULD EQUAL PAT
2046	7040	CMA	
2047	1051	TAD Z PAT	/COMPARE RARRTR WITH PAT
2050	7040	CMA	/AC SHOULD EQUAL ZERO
2051	7450	SNA	
2052	7430	SZL	
2053	5715	JMP I ERSWIX	/JUMP TO ERROR SWITCHES
2054	1060	TAD K4000	
2055	0051	AND Z PAT	/MASK BIT 0 OF PAT
2056	7040	CMA	
2057	1053	TAD Z LFTLNK	/COMPARE LFTLNK WITH PAT
2060	7040	CMA	/BIT 0
2061	7440	SZA	
2062	5715	JMP I ERSWIX	/JUMP TO ERROR SWITCHES
2063	1055	TAD Z RITLNK	
2064	7040	CMA	
2065	1140	TAD Z LNKSTR	/COMPARE PAT LINK WITH RITLNK
2066	7040	CMA	
2067	7440	SZA	
2070	5715	JMP I ERSWIX	
2071	5751	JMP I SXOKX1	
2072	7360	SETLNK, CLA CMA STL	/SET LINK
2073	5227	JMP REROT1	
2074	4316	GEN2, JMS HSEKP	
2075	4142	CONT2, JMS Z CX	
2076	0051	AND Z PAT	
2077	7001	IAC	
2100	3051	DCA Z PAT	/STORE INCREMENTED PATTERN
2101	7420	SNL	
2102	5311	JMP CLLINK	/JUMP TO CLEAR LNKSTR
2103	1060	TAD K4000	
2104	3140	DCA Z LNKSTR	/SET LNKSTR TO 4000
2105	4363	PT1EXX, JMS EX1	
2106	7440	SZA	
2107	5714	JMP I ROT2X	
2110	5332	JMP ROTOK	/EXIT ROTATE TESTS

2111	7200	CLLINK,	CLA	
2112	3140	DCA Z	LNKSTR	
2113	5305	JMP	PT1EXX	
2114	2200	ROT2X,	ROT2	
2115	2400	ERSWIX,	ERRSW1	
2116	0000	HSEKP,	0	
2117	7300	CLA	CLL	
2120	3051	DCA Z	PAT	
2121	3052	DCA Z	RALRTL	
2122	3054	DCA Z	RARRTR	
2123	3053	DCA Z	LFTLNK	
2124	3055	DCA Z	RITLNK	
2125	3140	DCA Z	LNKSTR	
2126	7000	NOP		
2127	7000	NOP		
2130	7000	NOP		
2131	5716	JMP I	HSEKP	
2132	7200	ROTOK,	CLA	
2133	4041	JMS Z	CRLF	/CRLF
2134	1075	TAD Z	R	/R
2135	4020	JMS Z	PRXLOP	
2136	1107	TAD Z	0	/0
2137	4020	JMS Z	PRXLOP	
2140	1100	TAD Z	T	/T
2141	4020	JMS Z	PRXLOP	
2142	4041	JMS Z	CRLF	/CRLF
2143	1113	TAD Z	TWO	/2
2144	4020	JMS Z	PRXLOP	
2145	1114	TAD Z	B	/B
2146	4020	JMS Z	PRXLOP	
2147	5750	JMP I	ARITH	
2150	0200	ARITH,	ARITHT	
2151	2521	SXOKX1,	SWOKX1	
2152	0000	EX,	0	
2153	1140	TAD Z	LNKSTR	
2154	7440	SZA		
2155	7410	SKP		
2156	5220	JMP	ROT1	
2157	7240	CLA	CMA	
2160	0051	AND Z	PAT	
2161	7040	CMA		
2162	5752	JMP I	FX	
2163	0000	EX1,	0	
2164	1140	TAD Z	LNKSTR	
2165	7440	SZA		
2166	7410	SKP		
2167	5714	JMP I	ROT2X	
2170	7240	CLA	CMA	
2171	0051	AND Z	PAT	
2172	7040	CMA		
2173	5763	JMP I	EX1	

*2200

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2200 7300 ROT2,      CLA CLL
2201 3056 DCA Z TST1      /CLEAR TEST FLAG
2202 7340 CLL CLA CMA
2203 0140 AND Z LNKSTR
2204 7440 SZA
2205 5250 JMP STLNK
2206 7140 CLL CMA
2207 0051 REROT2,     AND Z PAT      /BRING UP PATTERN
2210 7012 RTR
2211 3054 DCA Z RARRTR    /STORE RTR PATTERN
2212 7430 SZL            /SKIP IF LINK EQUALS A ZERO
2213 1072 TAD Z K0002    /SET RTR LINK STORE
2214 3055 DCA Z RITLNK   /CLEAR RTR LINK STORE
2215 1054 TAD Z RARRTR
2216 7006 RTL
2217 3052 DCA Z RALRTL    /STORE RTL PATTERN
2220 7430 SZL
2221 1060 TAD Z K4000    /SET RTL LINK STORE
2222 3053 DCA Z LFTLNK   /CLEAR RTL LINK STORE
2223 7100 CLL
2224 1052 TAD Z RALRTL    /RALRTL SHOULD EQUAL PAT
2225 7040 CMA
2226 1051 TAD Z PAT      /COMPARE RALRTL WITH PAT
2227 7040 CMA
2230 7440 SZA
2231 5652 JMP I ERSW2X    /JMP TO ERROR SWITCHES
2232 1072 TAD Z K0002    /COMPARE ROTLNK WITH PAT BIT 10
2233 0051 AND Z PAT      /MASK BIT 10 OF PAT
2234 7040 CMA
2235 1055 TAD Z RITLNK
2236 7040 CMA
2237 7440 SZA
2240 5652 JMP I ERSW2X
2241 1053 TAD Z LFTLNK    /LFT LINK SHOULD EQUAL LNKSTR
2242 7040 CMA
2243 1140 TAD Z LNKSTR    /COMPARE LFTLNK WITH LNKSTR
2244 7040 CMA
2245 7440 SZA
2246 5652 JMP I ERSW2X    /JUMP TO ERROR SWITCHES
2247 5653 JMP I SXOKX2

2250 7360 STLNK,      CLA CMA STL
2251 5207 JMP REROT2

2252 2406 ERSW2X,     ERRSW2
2253 2525 SXOKX2,     SWOKX2
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*2400
2400 7200 ERRSW1,      CLA
2401 1244   TAD ROTX1
2402 3215   DCA ERIN           /SCOPE MODE RJMP ADDRESS
2403 1245   TAD CONTX1
2404 3214   DCA CONTX           /CONTINUE MODE RJMP ADDRESS
2405 5216   JMP ERSW
2406 7200 ERRSW2,      CLA
2407 1250   TAD ROTX2
2410 3215   DCA ERIN           /SCOPE MODE RJMP ADDRESS
2411 1251   TAD CONTX2
2412 3214   DCA CONTX           /CONTINUE MODE RJMP ADDRESS
2413 5216   JMP ERSW

2414 0000   CONTX,        0
2415 0000   ERIN,         0
2416 7604   ERSW,         CLA OSR           /READ IN SWITCHES
2417 0062   AND Z K1000           /MASK BIT 2
2420 7040   CMA
2421 1062   TAD Z K1000
2422 7040   CMA
2423 7450   SNA               /TEST BIT 2 SWITCH
2424 4255   JMS ROPR
2425 7604   CLA OSR
2426 0060   AND Z K4000           /MASK BIT 0
2427 7040   CMA
2430 1060   TAD Z K4000
2431 7040   CMA
2432 7450   SNA               /TEST BIT 0 SWITCH
2433 7402   HLT               /ERROR HALT
2434 7604   SWOK,          CLA OSR
2435 0061   AND Z K2000           /MASK BIT 1
2436 7040   CMA
2437 1061   TAD Z K2000
2440 7040   CMA
2441 7450   SNA               /TEST BIT 1 SWITCH
2442 5615   JMP I ERIN           /JMP TO SCOPE MOD
2443 5614   JMP I CONTX         /JMP TO CONTINUE MODE

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2444	2020	ROTX1,	ROT1	
2445	2001	CONTX1,	CONT1	
2446	2000	GEN1X1,	GEN1	
2447	2074	GEN2X2,	GEN2	
2450	2200	ROTX2,	ROT2	
2451	2075	CONTX2,	CONT2	
2452	2464	TWOROX,	TWORO	
2453	2465	FINPRX,	FINPR	
2454	2650	RARPRX,	RARPR	
2455	0000	ROPR,	Ø	/RJMP TO SWITCH ROUTINE
2456	4026	JMS Z	CRLFLF	/PRINT CR LF LF
2457	4714	JMS I	PATPRX	/PRINT PAT
2460	7200	CLA		
2461	1056	TAD Z	TST1	
2462	7440	SZA		
2463	5266	JMP	ROT1PR	/PRINT ROTATE ONE PATTERN
2464	4715	TWORO,	JMS I ROT2PX	/PRINT ROTATE TWO PATTERN
2465	5655	FINPR,	JMP I ROPR	
2466	7200	ROT1PR,	CLA	
2467	1254	TAD	RARPRX	
2470	3714	DCA I	PATPRX	
2471	4041	JMS Z	CRLF	/PRINT CR LF
2472	7200	CLA		
2473	1075	TAD Z	R	/R
2474	4020	JMS Z	PRXLOP	
2475	1076	TAD Z	A	/A
2476	4020	JMS Z	PRXLOP	
2477	1077	TAD Z	L	/L
2500	4020	JMS Z	PRXLOP	
2501	1102	TAD Z	SP	/SP
2502	4020	JMS Z	PRXLOP	
2503	1053	TAD Z	LFTLNK	
2504	7440	SZA		
2505	5716	JMP I	LNONER	/LEFT LINK PRINT ONE
2506	4717	JMS I	ZERORX	/LEFT LINK PRINT ZERO
2507	1102	ROIX,	TAD Z SP	
2510	4020	JMS Z	PRXLOP	/SP
2511	1052	TAD Z	RALRTL	
2512	3057	DCA Z	PROUT	
2513	5720	JMP I	COUNXX	/PRINT RALRTL CONTENTS
2514	2600	PATPRX,	PATPR	
2515	2732	ROT2PX,	ROT2PR	
2516	2676	LNONER,	LNONE	
2517	2702	ZERORX,	ZEROR	
2520	2616	COUNXX,	COUNPR	
2521	7200	SWOKX1,	CLA	
2522	1245	TAD	CONTX1	
2523	3214	DCA	CONTX	
2524	5234	JMP	SWOK	
2525	7200	SWOKX2,	CLA	
2526	1251	TAD	CONTX2	
2527	3214	DCA	CONTX	
2530	5234	JMP	SWOK	

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*2600
2600 0000 PATPR,      0
2601 1101 TAD Z P          /P
2602 4020 JMS Z PRXLOP
2603 1076 TAD Z A          /A
2604 4020 JMS Z PRXLOP
2605 1100 TAD Z T          /T
2606 4020 JMS Z PRXLOP
2607 1102 TAD Z SP        /SP
2610 4020 JMS Z PRXLOP
2611 4361 JMS PLINK
2612 1102 TAD Z SP
2613 4020 JMS Z PRXLOP    /SP
2614 1051 TAD Z PAT
2615 3057 DCA Z PROUT      /STORE GENERATED PATTERN

2616 4231 COUNPR,      JMS MINDEX          /JMS TO MASK INDEX ROUTINE
2617 0137 AND Z COUNTX
2620 3112 DCA Z STRCNT
2621 2112 LSTBIT,      ISZ Z STRCNT
2622 7410 SKP
2623 5600 JMP I PATPR          /12 COUNTS FINISHED
2624 7200 CLA
2625 1057 TAD Z PROUT
2626 0410 AND I Z 10
2627 4237 JMS ONZER
2630 5221 JMP LSTBIT

2631 0000 MINDEX,      0
2632 7200 CLA
2633 1074 TAD Z XPROUT      /INDEX STARTING ADDRESS
2634 3010 DCA Z 10          /STORE INDEX ADDRESS
2635 7240 CLA CMA
2636 5631 JMP I MINDEX

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2637	0000	ONZER,	0	
2640	7440	SZA		
2641	5244	JMP ONEP		/JMP TO PRINT ONE
2642	4302	JMS ZEROR		
2643	5637	JMP I ONZER		
2644	7240	ONEP,	CLA CMA	
2645	0106	AND Z ONE		
2646	4020	JMS Z PRXLOP		/PRINT ONE
2647	5637	JMP I ONZER		
2650	7200	RARPR,	CLA	
2651	1273	TAD FINPRN		
2652	3200	DCA PATPR		
2653	4041	JMS Z CRLF		/CR LF
2654	7200	CLA		
2655	1075	TAD Z R		/R
2656	4020	JMS Z PRXLOP		
2657	1076	TAD Z A		/A
2660	4020	JMS Z PRXLOP		
2661	4323	JMS RSPACE		/R SP
2662	1055	TAD Z RITLNK		
2663	7440	SZA		
2664	5307	JMP LNONEX		/RIT LINK EQUALS A ONE
2665	4302	JMS ZEROR		
2666	1102	RO1XX,	TAD Z SP	/SP
2667	4020	JMS Z PRXLOP		
2670	1054	TAD Z RARRTR		
2671	3057	DCA Z PROUT		
2672	5216	JMP COUNPR		/PRINT RARR TR CONTENTS
2673	2465	FINPRN,	FINPR	
2674	2507	RO1XR,	RO1X	
2675	2744	RTLPRX,	RTLPR	

2676	7240	LNONE,	CLA CMA	
2677	0106	AND Z ONE		
2700	4020	JMS Z PRXLOP		/PRINT LINK
2701	5674	JMP I R01XR		
2702	0000	ZEROR,	Ø	
2703	7240	CLA CMA		
2704	0105	AND Z ZERO		
2705	4020	JMS Z PRXLOP		/PRINT Ø LINK
2706	5702	JMP I ZEROR		
2707	7200	LNONEX,	CLA	
2710	1106	TAD Z ONE		
2711	4020	JMS Z PRXLOP		
2712	5266	JMP R01XX		
2713	0000	RTCRLF,	Ø	
2714	7200	CLA		
2715	4041	JMS Z CRLF		/CR LF
2716	1075	TAD Z R		/R
2717	4020	JMS Z PRXLOP		
2720	1100	TAD Z T		/T
2721	4020	JMS Z PRXLOP		
2722	5713	JMP I RTCRLF		
2723	0000	RSPACE,	Ø	
2724	7200	CLA		
2725	1075	TAD Z R		/R
2726	4020	JMS Z PRXLOP		
2727	1102	TAD Z SP		/SP
2730	4020	JMS Z PRXLOP		
2731	5723	JMP I RSPACE		

2732	7200	ROT2PR,	CLA	
2733	1275	TAD	RTLPRX	
2734	3200	DCA	PATPR	
2735	4313	JMS	RTCRLF	/CR LF RT
2736	4323	JMS	RSPACE	/R SP
2737	1055	TAD	Z RITLNK	
2740	7440	SZA		
2741	5307	JMP	LNONEX	/RIGHT LINK EQUALS A ONE
2742	4302	JMS	ZEROR	/PRINT 0 LINK
2743	5266	JMP	RO1XX	/PRINT SP AND RARRTR CONTENTS
2744	7200	RTLPR,	CLA	
2745	1273	TAD	FINPRN	
2746	3200	DCA	PATPR	
2747	4313	JMS	RTCRLF	/CR LF RT
2750	1077	TAD	Z L	/L
2751	4020	JMS	Z PRXLOP	
2752	1102	TAD	Z SP	/SP
2753	4020	JMS	Z PRXLOP	
2754	1053	TAD	Z LFTLNK	
2755	7440	SZA		
2756	5276	JMP	LNONE	/PRINT 1 LINK
2757	4302	JMS	ZEROR	/PRINT 0 LINK
2760	5674	JMP	I RO1XR	
2761	0000	PLINK,	0	
2762	1140	TAD	Z LNKSTR	/PRINT PAT LINK
2763	4237	JMS	ONZER	
2764	5761	JMP	I PLINK	

@A	0076
ADD	0214
ADDISM	0235
ADDX	4050
AISM	0244
ARGXXX	0640
ARITH	2150
ARITHT	0200
AXISM	0265
B	0114
BISM	0272
BITSTR	0125
BW1	0117
CISM	0305
CL	0152
CLLINK	2111
CLRLNK	2015
CNTR	0123
CONHFD	0561
CONTX	2414
CONTX1	2445
CONTX2	2451
CONT1	2001
CONT2	2075
COUNPR	2616
COUNT	0111
COUNTX	0137
COUNXX	2520
CR	0104
CRLF	0041
CRLF1F	0026
CRY	0120
CX	0142
CXM	4075
CXN	4074
U	0131
UISM	0302
ERIN	2415
ERROR	0400
ERRSW1	2400
ERRSW2	2406
ERSW	2416
ERSWIX	2115
ERSW2X	2252
ERX	4076
EX	2152
EX1	2163
FCOMP	4051
FINPR	2465
FINPRN	2673
FINPRX	2453
G	0130
GEN1	2000
GEN1X1	2446
GEN2	2074
GEN2X2	2447
HEADFR	0124
HEADCON	0600
HEURJ	0563
HSEKP	2116
INCR	0223
INCR1	0415
INCRX	0224

K	0110
K0001	0073
K0002	0072
K0004	0071
K0010	0070
K0020	0067
K0040	0066
K0100	0065
K0200	0064
K0400	0063
K1000	0062
K2000	0061
K4000	0060
K7377	0141
L	0077
LCOMP	4077
LF	0103
LFTLNK	0053
LINK	0134
LIST	4200
LISTX	4015
LNKSTR	0140
LNONF	2676
LNONFR	2516
LNONFX	2707
LPXX	0022
LRX	4122
LRY	4123
LSTBIT	2621
MANYSP	0562
MESSG	0466
MINDFX	2631
M144	4014
NBIT	0472
NOERR	0407
NOERX	4124
O	0107
ODEVFN	4017
UNE	0106
ONEP	2644
ONZER	2637
P	0101
PADDOK	0312
PAT	0051
PATPR	2600
PATPRX	2514
PLINK	2761
PRERR	0423
PRHEAD	0521
PRINT	0416
PRONF	0506
PROUT	0057
PRSPAC	0512
PRXLOP	0020
PRZERO	0504
PTOTAL	0436
PT1EX	2011
PT1EXX	2105
R	0075
RALRTL	0052
RAND	4020
RAND1	4030
RAND2	4000

RARPR	2650
RARPRX	2454
RARRTR	0054
RCNT	4016
REROT1	2027
REROT2	2207
RITLNK	0055
RJHED	0625
ROPR	2455
ROTATE	0336
ROTOK	2132
ROTX1	2444
ROTX2	2450
ROT1	2020
ROT1PR	2466
ROT2	2200
ROT2PR	2732
ROT2PX	2515
ROT2X	2114
RO1X	2507
RO1XR	2674
RO1XX	2666
RSPACE	2723
RTCRLF	2713
RTLPR	2744
RTLPRX	2675
SETLNK	2072
SL	0150
SP	0102
SPAC06	0126
SPACST	0127
SPA06	0530
SPA12	0632
STLNK	2250
STRCNT	0112
STRXY	0225
SUM	0122

SWOK	2434
SWOKX1	2521
SWOKX2	2525
SXOKX1	2151
SXOKX2	2253
SXY	0414
T	0100
TOTAL	0121
TST1	0056
TWELVE	0626
TWO	0113
TWORO	2464
TWOROX	2452
WD1	0115
WD2	0116
X	0132
XARG	0135
XFCOMP	0337
XONZFR	0435
XPROUT	0074
XSTRXY	4047
XTOTAL	0451
XZEROR	0564
Y	0133
YARG	0136
ZERO	0105
ZEROR	2702
ZERORX	2517
U	