

- 1. IDENTIFICATION
- 1.1 Maindec 845
- 1.2 PDP-8 A/D Converter
- 1.3 July 20, 1966



2. ABSTRACT

The A/D Converter Test for the 138E/139E and 189 converters is a set of routines designed for maintenance personnel to aid in debugging hardware troubles, and as a periodic confidence check for data flags, interrupts, monotonicity, steady state accuracy, multiplexer selection and incrementation ability of the multiplexer.

3. REQUIREMENTS

3.1 Storage

The program uses memory 0 to 1500, and 6001 to 6100.

3.2 Subprograms and/or Subroutines (None)

3.3 Equipment

Standard PDP-8, Automatic A/D Converter Tester\*, A/D converter 138E with or without multiplexer 139E, or the 189 A/D converter. In lieu of the automatic tester, a high accuracy voltage standard should be used for manual check out.

3.3.1 6032 KCC is used to clear the automatic tester.  
6034 KRS is used to increment the automatic tester.

3.3.2 For automatic clearing and incrementing of the automatic tester, connections must be made between IOT terminal points on the computer and connecting points on the automatic tester.

3.3.3 The digital-to-analog output of the automatic tester can be connected to the multiplexer input or directly to the A/D input.

4. USAGE

4.1 Loading

The program is in binary format. Load the program into core by following the instructions published for the particular binary format loader being used.

4.2 Calling Sequence

4.2.1 If a voltage standard is being used in place of the automatic tester, use 660 as a starting address, and the program comes to a normal halt. Then go to one of the following six starting addresses.

4.2.4 For initial start-up using the tester, use one of these six addresses; or use these addresses after manual start-up is used.

Mode	138E	189
10 Bit	613	626
11 Bit	611	622
12 Bit	600	616

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\* Automatic A/D Converter Tester #7605039-0

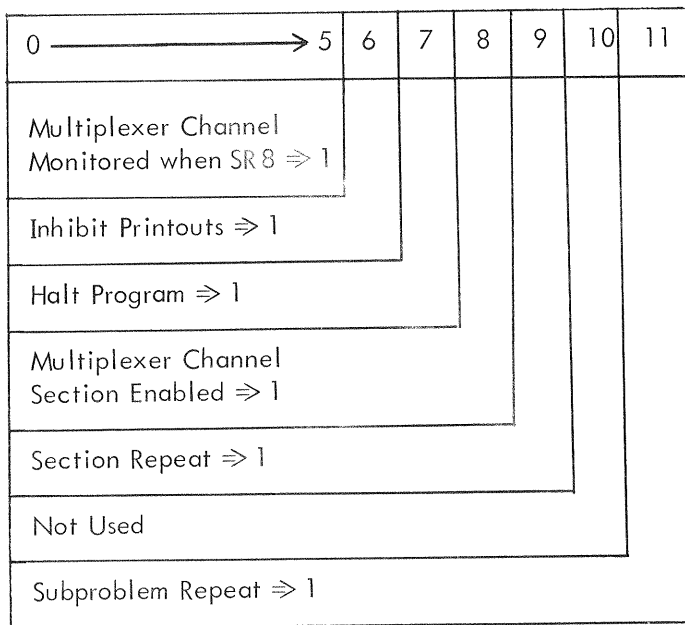
4.2.3 Multiplexer Test - For an automatic test of all switches for the multiplexer, go to one of the six initial start-up addresses, halt, then go to address 1000 to start.

4.2.4 For automatic recycle at the maximum multiplexer switch, memory location switch\* should equal maximum switch number.

4.3 Switch Settings

For normal operation with no errors, all switches can be down. For looping, inhibiting printouts, and selecting multiplexer channel, the switches may be used as follows:

- SR 0 to 5 Multiplexer Channel
- SR 6 = 1 Inhibit Printouts
- SR 7 = 1 Halt at End of Sub Test
- SR 8 = 1 Use SR 0 to 5 as Multiplexer Channel
- SR 9 = 1 Subsection Repeat
- SR 10 = 1 Not Used
- SR 11 = 1 Subproblem Repeat



4.4 Start-Up and/or Entry

4.4.1 Manual - Use SA = 660. Then use one of the following starting addresses.

- 4.4.2 Auto -
- 138E 10 Bit Mode SA = 613
  - 138E 11 Bit Mode SA = 611
  - 138E 12 Bit Mode SA = 600
  - 189 10 Bit Mode SA = 626
  - 189 11 Bit Mode SA = 622
  - 189 12 Bit Mode SA = 616

\*Switch = 142

- 4.4.3 Automatic incrementation of Mux channel: SA = 1000
- 4.4.4 To loop on done flag: SA = 601 and SR 11 ⇒1
- 4.4.5 To loop on interrupt: SA = 604 and SR 11 ⇒1
- 4.4.6 To loop steady state accuracy: SA = 407 and SR 9 ⇒1
- 4.4.7 To loop monotonicity: SA = 402 and SR 9 ⇒1
- 4.4.8 Start address for manual: SA ⇒ 660
- 4.4.9 Restart for A/D test: SA = 400
- 4.4.10 To loop on steady state read: SA = 400 and SR 11 ⇒1
- 4.4.11 To display 138E converted value in AC: SA = 1050
- 4.4.12 To display 189 converted value in AC: SA = 1075
- 4.5 Errors in Usage
- 4.5.1 All errors are covered by printouts.

Printouts	Manual	Auto	138E	189	Meaning
No Flag	X	X	X		Unable to raise flag
No Interrupt	X	X	X		Unable to raise interrupt
Interrupt Up	X	X	X		Interrupt always UP will not drop
XXXX>1.25		X	X	X	Narrow voltage state Voltage less than 1.25 mv
XXXX DIP		X	X	X	Switching point greater than 1 LSB
Limits Bad		X	X	X	Voltage scale incorrect
3 States XXXX/.XX/-XX/+XX		X	X	X	3 stating error, number of times at value, below, above
Pass Complete		X	X	X	One pass of monotonicity and steady state
Pass Complete Sw XX		X	X		Same as above except automatic incrementation of multiplexer switch
XXXX/.XX/-XX/+XX	X		X	X	Manual check only showing rela- tive values

4.5.2 Do not use initial start address more than once, restart all testing at 400, except for the automatic multiplexer incrementation switch test which starts at 1000.

#### 4.6 Error Recovery

No halt occurs unless requested by the switch register (SR7). Depress CONTINUE to recover.

## 5. RESTRICTIONS

### 5.1 Status Active Register

Autoindex Registers 10 and 11 are used by the program.

### 5.2 Status of Core

The main program uses core in the area 0 to 1500 for program storage and core 6001 and 6100 as converted data storage.

## 6. DESCRIPTION

### 6.1 Discussion

This package contains routines to aid the operator in troubleshooting the equipment, assuring him of its correct operation. The nature of analog-to-digital converters precludes a completely automatic diagnostic type of program. To this objective, the status printouts show:

1. Three stating conditions
2. Voltage states that are very narrow
3. Improper voltage limits

These checks are made by two tests: one checking steady state accuracy and the other checking monotonicity. A correlation should exist between printouts generated by these two tests to indicate a calibration or a digital error. If a relationship cannot be found, this indicates the printouts were due to noise pickup and/or poor grounds.

### 6.2 Examples and/or Applications

6.2.1 Monotonicity is one way to assure that all bits are meaningful. This means that all states must exist and must be in the correct order. In terms of converter operation, as the number going to the digital-to-analog converter is increased, the output voltage must also increase; it should never dip back down at any point. Similarly, if the input voltage to analog-to-digital converter is increased, the digital output should stay in the same value or increase and should not skip over any states.

6.2.2 Steady state accuracy is one way to measure the repeatability of the converter. If a voltage going to an analog-to-digital converter remains constant, the converted digital value should maintain an accuracy of  $\pm 1/2$  LSB. This means that there may be two acceptable converted digital values for one analog voltage in.

### 6.3 Scaling

The only type of scaling used is word length, and this is accomplished by using the correct starting address. Memory location mode contains the correct scale factor.

$$12\text{-Bit Word (Mode)} = 1_{(8)}$$

$$11\text{-Bit Word (Mode)} = 2_{(8)}$$

$$10\text{-Bit Word (Mode)} = 4_{(8)}$$

If there is a need to go to a smaller word, the value in Mode may be changed manually after using one of the six starting addresses, then restarting at 400, (i.e., 9-Bit Word (Mode) =  $10_{(8)}$ ).

7. METHODS

7.1 Discussion

See paragraph 6.1.

8. FORMAT

8.1 Input Data

Input data is an analog voltage converted to a digital value by the analog-to-digital converter.

8.2 Core Data

The core data is the output of the analog-to-digital converter. This data is stored in core 6001 to 6100.

8.3 Output Data (Not Applicable)

8.4 Miscellaneous

8.4.1 Three-stating printout (11-Bit Mode)

(a) 3 States 1376/.44/-25/+05

(b) 3 States 1374/.17/-00/+03

(c) 3 States 1400/.06/-27/+00

(d) 3 States 1376/.00/-24/+52

The above printouts were caused by a three stating of the analog-to-digital converter. A field of 77(8) conversions of the same analog value are stored in a buffer. The first word in the buffer is used as a reference word; a record is made each time the reference word, a value less than the reference word, and a value greater than the reference word are found. For example, in (a) 1376 was the first word in the buffer and was found 44(8) times, 1374 was found 25(8) times and 1400 was found 05(8) times.

1372	
1374	} 3 Stating Values
1376	
1400	
1402	

In (b) it is not quite as clear, the first word was 1374 and was found 17(8) times, the value below it was not found at all, the value above it was found 3(8) times.

1372	Not found	
1374	Reference word	
1376	3 Times	} 3 Stating Values
1400	The third state	
1402		

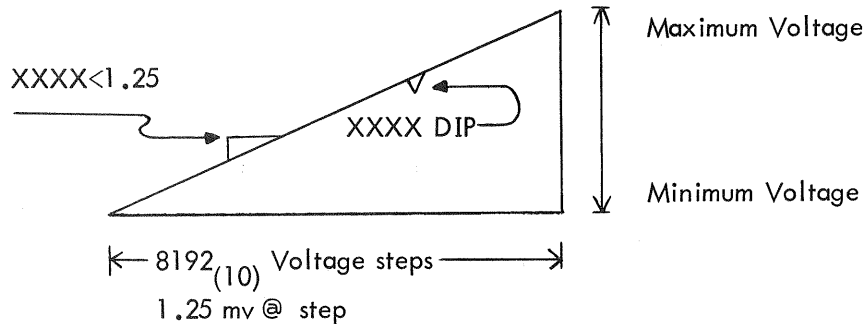
The reference word is not made the center value of a three stating condition, therefore it is possible for one of the values to show as occurring 00 times. In case (c) it was the value above the reference value that was not found.

1372		} 3 Stating Values
1374	The third state	
1376	27 times	
1400	Reference	
1402	Not found	

Case (d) is a rare condition where the three stating conditions only occurred one time and it was the reference value, the first word in the buffer, which caused the three stating condition. An inspection of the buffer area 6001 to 6100 shows the value stored.

#### 8.4.2 Monotonicity printouts (11-Bit Mode)

- (a) 1376 < 1.25
- (b) 6732 DIP
- (c) Bad limits



Case (a) is where the converted value 1374 was found, but before 1376 was found the converted value 1400 was reached. This infers that the voltage state which generates the converted value is less than 1.25 mv wide.

Case (b) is when 6730 was the previous voltage stored, the value 6732 is the next expected value. Instead of storing the same or increasing, the next converted value decreases to 6724.

Case (c) is when the last converted value at the end of the test does not agree with a predicted value. This indicates need of readjustment of gain or off set.

#### 9. EXECUTION TIME

Each pass takes about one minute (with printouts the time increases).

#### 10. PROGRAM

10.1 Core Map (None)

10.2 Dimension List(s) (None)

10.3 Macro, Parameter, and Variable Lists (None)



10.4

Program Listing

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/A/D CONVERTER
/CONSTANTS

*01
0001 6002 IOF
0002 5403 JMP I .+1
0003 1547 INTENT+14

*20
0020 0001 SWTEST, 0001 /SUB PROBLEM RPT
0021 0002 0002 /SUB SECTION RPT
0022 0004 0004 /SECTION RPT
0023 0010 0010 /SEL MUX CHANNEL
0024 0020 0020 /HALT
0025 0040 0040 /PRINT

/FOR PRINT
0026 0007 MASKA, 0007 /CHAR MASK
0027 0000 0 /TEM STORAGE
0030 0070 MASKB, 0070 /MASK
0031 0000 0 /TEM STORAGE
0032 0700 MASKC, 0700 /MASK
0033 0000 0 /TEM STORAGE

0034 7000 MASKD, 7000 /MASK
0035 0000 0 /TEM STORAGE
0036 6060 6060 /CONSTANT FOR NUMBERS
0037 0000 TEMPE, 0 /STORAGE
0040 0000 DATA, 0000 /GENERATE DATA FOR TEST
0041 6000 INBUFF, 6000 /IN COUNTER
0042 6100 TBUFF, 6100 /DATA BUFFER UPPER LIMITS
0043 6000 INLL, 6000 /LOWER LIMIT CONSTANT
0044 6100 TESTL1, 6100 /LOWER LIMIT CONSTANT
0045 6101 TESTL2, 6101 /TEST BUFFER UPPER LIMITS
0046 0000 BAD, 0 /BAD DATA
0047 0002 CON1, 0002 /UP DOWN COUNT
0050 0000 TEM1, 0 /TEMP STORAGE UP DOWN

0051 7701 LOOP, 7701 /LOOP COUNT
0052 0000 0 /LOOP COUNTER DATA
0053 0000 0 /LOOP COUNTER SECTION
0054 0000 0

0055 0000 MODE, 0 /MODE STORAGE
0056 0631 XI189, I189 /INSTRUCTION CONVERSION 189
0057 1522 XDFLA, DTFLAG /CHECK FOR DONE FLAG
0060 1533 XINTEN, INTENT /CHECK FOR INTERRUPT
0061 0567 XINSTA, INSTA /FORCE PRINT OUT
0062 0547 XINSTB, INSTB /REMOVE ERROR PRINTOUT

/CONSTANTS
0063 0046 XBAD, BAD
0064 0200 XMSSG, MESSAGE
0065 0672 XTEXTA, TEXTA /3 STATES
0066 0703 XTEXTB, TEXTB /CR AND LF
0067 1366 XTEXTC, TEXTC /XX DIP

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```

0070 0000 XLOOP,      0
0071 5470   JMP I  .-1
0072 1261 XERR,      HALT
0073 0000   0000
0074 0000 CHAN,      0           /CHANNEL COUNTER
0075 0000 BWORD,     0           /WORD BUFFERED IN
0076 4001 TESTA,    4001
0077 4000 TESTB,    4000
0100 3777 TESTC,    3777
0101 0000 STSW,     0           /SWITCH STORAGE
0102 0710 XSPL,     SPL        /SUB PROBLEM LOOP
0103 0571 XINC,     INC        /SET+1 TO MUX
0104 1261 XHALT,    HALT
0105 0732 XMUX39,   MUX39E     /INCREMENT MUX
0106 0000 FLAG,     0
0107 1200 XTRXAL,   TRXAL
0110 7776 MASKF,    7776

0111 0453 XSTDAT,   STDATA
0112 0000 PTEX,     0           /COUNT FROM ETABLE

0113 7735   7735           /FIELD COUNT
0114 0000   0             /COUNTER
0115 1346 XTEXTE,   TEXTE      /PASS COMPLETE
0116 1361 XTEXTF,   TEXTF     /SPACE MINUS
0117 0717 XTEXTG,   TEXTG     /INTERRUPT OP ALL THE TIME

0120 0000 CTEMA,    0           /ORIGINAL MINUS ONE
0121 0000 CTEMB,    0           /ORIGINAL NUMBER
0122 0000 CTEMC,    0           /ORIGINAL PLUS ONE
0123 0000 CCONTA,   0           /A COUNTER
0124 0000 CCONTB,   0           /B COUNTER
0125 0000 CCONTC,   0           /C COUNTER
0126 0273 XER,      ER
0127 1513 XERDIP,   ERDIP      /VOLTAGE DIP
0130 1400 XALLNU,   ALLNUM     /ALL NMBER CHECK
0131 0400 XADTES,   ADTEST
0132 0421 XAUTO,    AUTO38
0133 0321 XTEXTK,   TEXTK      /3 STATEX/X/X/X/X/
0134 1504 XERNUM,   ERNUM
0135 0337 XTEXTL,   TEXTL     /XXXX <1.25
0136 1300 XTEXTM,   TEXTM     /NO FLAG
0137 1310 XTEXTN,   TEXTN     /NO INTERRUPT
0140 1323 XTEXTP,   TEXTP     /LIMITS BAD
0141 1335 XTEXTR,   TEXTR     /XXX DIP
0142 7777 SWITCH,   7777      /MANUAL INSERT OF MAX MUX SW
0143 0745 XTOXOR,   TOXOR     /VOLTAGE SETUP FOR 189
0144 0351 XXOR,     XOR        /EXCLUSIVE OR

/ALPHANUMERIC MESSAGE TYPEOUT SUBROUTINE

*200
0200 0000 MESSAGE,   0
0201 7604 LAS           /CHECK FOR PRINT
0202 0025 AND SWTEST+5 /XX4X
0203 7640 SZA CLA
0204 5206 JMP  .+2

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0205 5214 JMP .+7
0206 1110 TAD MASKF
0207 1200 TAD MESSAGE
0210 3200 DCA MESSAGE
0211 1600 TAD I MESSAGE
0212 3200 DCA MESSAGE
0213 5600 JMP I MESSAGE /NO PRINT
0214 7240 CLA CMA /SET C(AC) = -1
0215 1200 TAD MESSAGE /ADD LOCATION

0216 3010 DCA I0 /AUTO-INDEX REGISTER
0217 1410 TAD I 10 /FETCH FIRST WORD
0220 3231 DCA MSRGHT /SAVE IT
0221 1231 TAD MSRGHT
0222 7012 RTR
0223 7012 RTR /ROTATE 6 BITS RIGHT
0224 7012 RTR
0225 4232 JMS TYPECH /TYPE IT
0226 1231 TAD MSRGHT /GET DATA AGAIN
0227 4232 JMS TYPECH /TYPE RIGHT HALF
0230 5217 JMP MESSAGE+17 /CONTINUE
0231 0000 MSRGHT, 0 /TEMPORARY STORAGE

0232 0000 TYPECH, 0 /TYPE CHARACTER IN C(AC)6-11
0233 0263 AND MASK77
0234 7450 SNA /IS IT END OF MESSAGE?
0235 5410 JMP I 10 /YES: EXIT
0236 1264 TAD M40 /SUBTRACT 40
0237 7500 SMA /<40?
0240 5243 JMP .+3 /NO
0241 1265 TAD C340 /YES: ADD 300
0242 5256 JMP MTP /TO CODES <40
0243 1266 TAD M3 /SUBTRACT 3
0244 7440 SZA /IS IT ZERO?
0245 5250 JMP .+3 /NO
0246 1267 TAD C212 /YES: CODE 43 IS
0247 5256 JMP MTP /LINE-FEED (212)
0250 1270 TAD M2 /SUBTRACT 2
0251 7440 SZA /IS IT ZERO?
0252 5255 JMP .+3 /NO
0253 1271 TAD C215 /YES: CODE 45 IS
0254 5256 JMP MTP /CARRIAGE-RETURN (215)
0255 1272 TAD C245 /ADD 200 TO OTHERS >40
0256 6046 MTP, TLS /TRANSMIT CHARACTER
0257 6041 TSF /WAIT FOR FLAG
0260 5257 JMP .-1 /NOT SET YET
0261 7200 CLA /SET: CLEAR C(AC)
0262 5632 JMP I TYPECH /RETURN

/CONSTANTS
0263 0077 MASK77, 77
0264 7740 M40, -40
0265 0340 C340, 340
0266 7775 M3, -3
0267 0212 C212, 212
0270 7776 M2, -2
0271 0215 C215, 215
0272 0245 C245, 245

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```

                /SET UP FOR TEXTK
0273  5273  ER,          JMP .
0274  7200  CLA
0275  4507  JMS I XTRXAL      /PRINT
0276  6001  6001
0277  0325  TEXTK+4          /MSB
0300  0326  TEXTK+5
0301  4507  JMS I XTRXAL
0302  0124  CCONTB
0303  0000  0
0304  0330  TEXTK+7
0305  4507  JMS I XTRXAL
0306  0123  CCONTA
0307  0000  0          /MSB
0310  0332  TEXTK+11        /LSB
0311  4507  JMS I XTRXAL
0312  0125  CCONTC          /MSB
0313  0000  0          /LSB
0314  0334  TEXTK+13
0315  4465  JMS I XTEXTA
0316  4533  JMS I XTEXTK      /3 STATES
0317  4504  JMS I XHALT
0320  5673  JMP I FR

0321  5321  TEXTK,        JMP .
0322  4464  JMS I XMSSG
0323  4040  4040          /(VALUE) /./-/+
0324  4040  4040
0325  6060  6060          /VALUE
0326  6060  6060
0327  5756  5756          /.
0330  6060  6060          /COUNT
0331  5755  5755          /-
0332  6060  6060          /COUNT
0333  5753  5753          /+
0334  6060  6060          /COUNT
0335  0000  0000
0336  5721  JMP I TEXTK

0337  5337  TEXTL,        JMP .          /XXXX>1.25
0340  4464  JMS I XMSSG
0341  4543  4543
0342  6060  6060
0343  6060  6060
0344  4074  4074
0345  4061  4061
0346  5662  5662
0347  6500  6500
0350  5737  JMP I TEXTL
0351  5351  XOR,          JMP .          /EXCLUSIVE OR
0352  3365  DCA ALOC
0353  1751  TAD I XOR
0354  3366  DCA BLOC
0355  1365  TAD ALOC
0356  0766  AND I BLOC
0357  7041  CIA
0360  7104  CLL RAL

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```

0361 1365 TAD ALOC
0362 1766 TAD I BLOC
0363 2351 ISZ XOR
0364 5751 JMP I XOR
0365 0000 ALOC, 0
0366 0000 BLOC, 0
*400
0400 1101 ADTEST, TAD STSW
0401 6542 ADSC
0402 4530 JMS I XALLNU
0403 7604 LAS /0004
0404 0022 AND SWTEST+2
0405 7440 SZA
0406 5202 JMP .-4 /LOOP SECTION
0407 4221 JMS AUTO38
0410 7604 LAS
0411 0022 AND SWTEST+2
0412 7440 SZA
0413 5207 JMP .-4 /LOOP SECTION
0414 4505 JMS I XMUX39 /MUX CHANNEL
0415 4515 JMS I XTEXTE /PASS COMPLETE
0416 4466 JMS I XTEXTB /CR+LF
0417 4466 JMS I XTEXTB /CR+LF
0420 5200 JMP ADTEST

```

/A-D CONVERTER TEST

```

0421 5221 AUTO38, JMP .
0422 4232 JMS HOKEEP /HOUSEKEEPING
0423 4070 JMS XLOOP /SET UP FOR LOOP
0424 4253 JMS STDATA /STORE A/D CONVERTER
0425 4271 JMS COMPAR /COMPARE
0426 4502 JMS I XSPL /CHECK FOR SUB PROBLEM LOOP
0427 4503 JMS I XINC /INCREMENT AND CHECK FOR DONE
0430 4504 JMS I XHALT /CHECK FOR HALT
0431 5621 JMP I AUTO38 /DONE

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```

0432 5232 HOKEEP, JMP .
0433 7200 CLA /BASE DATA
0434 3040 DCA DATA /PRED DATA
0435 6032 KCC /CLEAR TESTER
0436 1051 TAD LOOP /LOOP COUNTER C.T.
0437 3052 DCA LOOP+1 /LOOP COUNTER
0440 1043 TAD INLL /CONSTANT
0441 3041 DCA INBUFF /TEMP
0442 1110 TAD MASKF
0443 3054 DCA LOOP+3 /K=2
0444 1044 TAD TESTL1 /CONSTANT
0445 3042 DCA TBUFF /TEMP
0446 1047 TAD CON1 /MONOTONIC CITY
0447 3050 DCA TEM1 /TEMP
0450 3106 DCA FLAG /ALTERNATE
0451 3053 DCA LOOP+2 /SECTION COUNTER
0452 5632 JMP I HOKEEP /RETURN

```

/STORE CONVERTED DATA IN CORE 6001 TO 6100 FOLLOW BY  
/STEADY STATE ACCURACY TEST

```

0453 5253 STDATA,      JMP .
0454 7200  CLA
0455 1043  TAD INLL      /6000
0456 3011  DCA 11        /CURRENT ADDRESS
0457 1051  TAD LOOP      /LOOP COUNT
0460 3052  DCA LOOP+1    /COUNTER
0461 6532  ADCV          /INIT CONVERTER
0462 6531  ADSF          /WAIT FOR FLAG
0463 5262  JMP .-1       /FOR 189 = JMP .+1
0464 6534  ADRB          /READ/CONVERTER
0465 3411  DCA I 11     /FIRST WORD 6001
0466 2052  ISZ LOOP+1    /COUNTER
0467 5261  JMP .-6       /READ MORE
0470 5653  JMP I STDATA

```

/COMPARE HOUSEKEEP

```

0471 5271  COMPAR,     JMP .
0472 7200  CLA
0473 1043  TAD INLL      /BASE 6000
0474 3011  DCA 11
0475 1051  TAD LOOP      /COUNT
0476 3052  DCA LOOP+1    /COUNTER
0477 2052  ISZ LOOP+1
0500 3120  DCA CTEMA      /DATA-1
0501 3121  DCA CTEMB      /DATA
0502 3122  DCA CTEMC      /DATA+1
0503 3123  DCA CCONTA     /COUNTER-1
0504 3124  DCA CCONTB     /COUNTER
0505 3125  DCA CCONTC     /COUNTER+1
0506 1411  TAD I 11
0507 3046  DCA BAD
0510 1046  TAD BAD
0511 7041  CIA
0512 3121  DCA CTEMB      /DATA
0513 1055  TAD MODE
0514 7041  CIA
0515 1121  TAD CTEMB
0516 3122  DCA CTEMC      /DATA+1
0517 1121  TAD CTEMB
0520 1055  TAD MODE
0521 3120  DCA CTEMA      /DATA-1

```

/START COMPARE

```

0522 1411  TAD I 11
0523 3046  DCA BAD
0524 1046  TAD BAD
0525 1120  TAD CTEMA
0526 7640  SZA CLA
0527 5332  JMP .+3       /TRY NEXT
0530 2123  ISZ CCONTA
0531 5345  JMP .+14      /INC LOOP+1
0532 1046  TAD BAD
0533 1121  TAD CTEMB
0534 7640  SZA CLA

```

```

0535 5340    JMP .+3                /TRY NEXT
0536 2124    ISZ CCONTB
0537 5345    JMP .+6                /INC LOOP+1
0540 1046    TAD BAD
0541 1122    TAD CTEMC
0542 7640    SZA CLA
0543 5345    JMP .+2
0544 2125    ISZ CCONTC
0545 2052    ISZ LOOP+1           /INC LOOP COUNTER
0546 5322    JMP .-24            /LOOP TILL DONE

/ANY ZERO
0547 7201    INSTB,          CLA IAC
0550 1123    TAD CCONTA        /A+1
0551 1124    TAD CCONTB        /A+B+1
0552 1125    TAD CCONTC        /A+B+C+1
0553 1051    TAD LOOP          /A+B+C+LOOP+1=0000
0554 7440    SZA
0555 5367    JMP .+12          /ERROR
0556 1123    TAD CCONTA
0557 7650    SNA CLA
0560 5671    JMP I COMPAR      /OK EXIT
0561 1124    TAD CCONTB
0562 7650    SNA CLA
0563 5671    JMP I COMPAR      /OK EXIT
0564 1125    TAD CCONTC
0565 7650    SNA CLA
0566 5671    JMP I COMPAR      /OK EXIT
0567 4526    INSTA,          JMS I XER          /NO ZERO COUNT FOUND
0570 5671    JMP I COMPAR      /EXIT

/INC. TESTER TEST FOR DONE

0571 5371    INC,            JMP .
0572 6034    KRS                /PLUS ONE TO TESTER
0573 2053    ISZ LOOP+2
0574 5470    JMP I XLOOP        /LOOP TO ST DATA
0575 2054    ISZ LOOP+3
0576 5470    JMP I XLOOP
0577 5771    JMP I INC          /EXIT

*600

/INITIAL START 138
0600 4215    START,          JMS BITLG          /12 BIT MODE 138
0601 4070    JMS XLOOP
0602 4457    JMS I XDTFLA      /DATA FLAG
0603 4502    JMS I XSPL
0604 4070    JMS XLOOP
0605 4460    JMS I XINTEN      /INTERRUPT CHECK
0606 4502    JMS I XSPL
0607 5531    JMP I XADTES
0610 0000    0
0611 4221    JMS BITLG+4      /11 BIT MODE 138
0612 5201    JMP START+1

0613 4225    JMS BITLG+10     /10 BIT MODE 138
0614 5201    JMP START+1

```

```

/INITIAL START 189
0615 0631 BITLG, I189
0616 1020 TAD SWTEST /12 BIT ENTRANCE 189
0617 3055 DCA MODE
0620 5615 JMP I .-3 /EXIT 12
0621 0631 I189
0622 1021 TAD SWTEST+1 /11 BIT ENTRANCE 189
0623 3055 DCA MODE
0624 5621 JMP I .-3 /EXIT 11 BIT
0625 0631 I189
0626 1022 TAD SWTEST+2 /10 BIT ENTRANCE 189
0627 3055 DCA MODE
0630 5625 JMP I .-3 /EXIT 10 BIT

/INSTRUCTION CONVERSION 189
0631 2643 I189, ISZ I .+12 /ST DATA+10 JMP
0632 2643 ISZ I .+11 /ST DATA+10 JMP
0633 2644 ISZ I .+11 /ALL NUM+11 JMP
0634 2644 ISZ I .+10 /ALL NUM+11 JMP
0635 1242 TAD .+5
0636 3646 DCA I .+10 /ST DATA+6 CONV
0637 1242 TAD .+3
0640 3645 DCA I .+5 /ALL NUM+7 CONV
0641 5247 JMP .+6 /TO AD TEST
0642 6004 ADC /CONVERT INST 189
0643 0463 STDATA+10 /JMP INST
0644 1411 ALLNUM+11 /JMP INST
0645 1412 ALLNUM+12 /CONVERT INST
0646 0464 STDATA+11 /CONVERT INST
0647 1253 TAD .+4
0650 3652 DCA I .+2
0651 5531 JMP I XADTES
0652 1407 ALLNUM+7
0653 4543 JMS I XTOXOR

*660
/ENTRANCE FOR MANUAL SET UP

0660 1066 TAD XTEXTB /CR+LF IN PLACE OF 3 STATE
0661 3065 DCA XTEXTA
0662 1461 TAD I XINSTA /FORCE PRINT OUT
0663 3462 DCA I XINSTB
0664 1034 TAD MASKD /REMOVE ERROR PRINT OUT
0665 3461 DCA I XINSTA
0666 1132 TAD XAUTO /FORCE TO LOOP STEADY STATE ACCURACY
0667 3130 DCA XALLNU
0670 7402 HLT
0671 5271 JMP .

/GO TO ENTRANCE 1 OF 6

/TFXT MULTIPLIFR

0672 5272 TEXTA, JMP .
0673 4464 JMS I XMSSG
0674 4543 4543 /3 STATES
0675 6340 6340
0676 2324 2324

```



```

0677 0124 0124
0700 0523 0523
0701 4000 4000
0702 5672 JMP I TEXTA

0703 5303 TEXTB, JMP .
0704 4464 JMS I XMSSG /CR/LF
0705 4543 4543
0706 0000 0
0707 5703 JMP I TEXTB

0710 5310 SPL, JMP . /0002 LOOP
0711 7604 LAS
0712 0020 AND SWTEST
0713 7450 SNA
0714 5710 JMP I SPL /NO LOOP
0715 4504 JMS I XHALT /LOOP CHECK FOR HALT
0716 5470 JMP I XLOOP /0022 LOOP HALT

0717 5317 TEXTG, JMP .
0720 4464 JMS I XMSSG /INTERRUPT ALWAYS UP
0721 4543 4543
0722 1116 1116
0723 2405 2405
0724 2222 2222
0725 2520 2520
0726 2440 2440
0727 2520 2520
0730 0000 0000
0731 5717 JMP I TEXTG

/SELECT MULTIPLEXER CHANNEL

0732 5332 MUX39E, JMP . /STOKE CHAN IN-STSW-
0733 7604 LAS
0734 0023 AND SWTEST+3 /CHECK FOR NEW MUX CHANNEL
0735 7450 SNA
0736 5732 JMP I MUX39E /EXIT NO CHANGE
0737 7604 LAS
0740 7112 CLL RTR
0741 7112 CLL RTR
0742 7112 CLL RTR /SHIFT RIGHT SIX
0743 3101 DCA STSW
0744 5732 JMP I MUX39E /EXIT
0745 5345 TOXOR, JMP . /SET UP VOLTAGE COUNT
0746 7200 CLA /FOR 189
0747 1124 TAD CCONTB
0750 4544 JMS I XXOR
0751 0077 TESTB
0752 3124 DCA CCONTB
0753 1125 TAD CCONTC
0754 4544 JMS I XXOR
0755 0077 TESTB
0756 3125 DCA CCONTC
0757 2070 ISZ XLOOP
0760 5745 JMP I TOXOR

/TEST ALL MULTIPLEXER SWITCHES
*1000

```

```

1000 6541 ADCC /CL MUX
1001 7200 CLA /CL COUNTER
1002 3101 DCA STSW /CL SWITCH STORAGE
1003 4530 JMS I XALLNU /MONO
1004 4532 JMS I XAUTO /STEADY STATE
1005 4515 JMS I XTEXTE /PASS COMPLETE
1006 4507 JMS I XTRXAL /
1007 0101 STSW /FROM
1010 0000 0
1011 1372 TEXTC+4 /TO
1012 4467 JMS I XTEXTC /MUX SW NUMBER
1013 6544 ADIC /INC SWITCH
1014 2101 ISZ STSW /INC COUNT
1015 7200 CLA /CHECK SWITCH LIMITS
1016 1142 TAD SWITCH /SWITCH CONTAINS MAX CHANNEL
1017 7040 CMA /NUMBER
1020 1101 TAD STSW
1021 7440 SZA
1022 5203 5203
1023 5200 5200 /EXIT

```

/138 CONVERTED DATA IN A.C.

\*1050

```

1050 7200 AC138E, CLA
1051 6532 ADCV /CONVERT
1052 6531 ADSF /WAIT FOR FLAG
1053 5252 JMP .-1
1054 6534 ADRB /READ BUFFER
1055 2262 ISZ .+5 /DELAY
1056 5255 JMP .-1
1057 2263 ISZ .+4
1060 5257 JMP .-1
1061 5250 JMP AC138E /LOOP
1062 0000 0
1063 0000 0

```

/189 CONVERTED DATA IN A.C.

\*1075

```

1075 6004 AC189, ADC
1076 5275 JMP .-1

```

\*1200

```

1200 0000 TRXAL, 0
1201 1210 TAD TRXAL+10
1202 3260 DCA TC /STORE INIT NEXT TIME
1203 7200 CLA
1204 1600 TAD I .-4 /ADDRESS OF OPERAND
1205 3207 DCA .+2
1206 5610 JMP I .+2
1207 0000 0 /ADDRESS OF OPERAND
1210 1212 TRXAL+12 /CHANGING REFERENCE(P)
1211 5203 JMP TRXAL+3
1212 1607 TAD I TRXAL+7 /AC (OPERAND)

```

1213	0026	AND MASKA	/0007
1214	3027	DCA MASKA+1	/000X
1215	1607	TAD I TRXAL+7	/AC(OPERAND)
1216	0030	AND MASKB	/0070
1217	3031	DCA MASKB+1	/00X0
1220	1607	TAD I TRXAL+7	/AC(OPERAND)
1221	0032	AND MASKC	/0700
1222	3033	DCA MASKC+1	/0X00
1223	1607	TAD I TRXAL+7	/AC(OPERAND)
1224	0034	AND MASKD	/700
1225	3035	DCA MASKD+1	/X000
1226	1033	TAD MASKC+1	/0X00
1227	7112	RTR CLL	
1230	7010	RAR	/0X00 RS3 00X0
1231	1035	TAD MASKD+1	/X0X0
1232	7012	RTR	
1233	7010	RAR	/X0X0 RS3 0X0X
1234	1036	TAD MASKD+2	/6060 + 0X0X = 6X6X
1235	3033	DCA MASKC+1	/TEMP STORAGE
1236	2200	ISZ TRXAL	/INCREMENT FOR STORAGE
1237	4210	JMS TRXAL+10	/FIND STORAGE ADDRESS
1240	1033	TAD MASKC+1	/6X6X
1241	3607	DCA I TRXAL+7	/STORE OPERAND AS SPECIFIED
1242	1031	TAD MASKB+1	/00X0
1243	7004	RAL	
1244	7006	RTL	/00X0 SL3 0X00
1245	1027	TAD MASKA+1	/0X00 + 000X = 0X0X
1246	1036	TAD MASKD+2	/0X0X + 6060 = 6X6X
1247	3035	DCA MASKD+1	/TEMP STORAGE
1250	2200	ISZ TRXAL	/INCREMENT FOR STORAGE
1251	4210	JMS TRXAL+10	/FIND STORAGE ADDRESS
1252	1035	TAD MASKD+1	/6X6X
1253	3607	DCA I TRXAL+7	/STORE OPERAND AS SPECIFIED
1254	1260	TAD TC	/HOUSEKEEPING
1255	3210	DCA TRXAL+10	
1256	2200	ISZ TRXAL	/INCREMENT FOR RETURN
1257	5600	JMP I TRXAL	/RETURN
1260	0000	TC, 0	
1261	5261	HALT, JMP .	/HALT IF SR7=1
1262	7604	LAS	
1263	0024	AND SWTEST+4	/0020
1264	7440	SZA	
1265	7402	HLT	
1266	5661	JMP I HALT	
		*1300	
1300	5300	TEXTM, JMP .	/NO FLAG
1301	4464	JMS I XMSSG	
1302	4543	4543	
1303	1617	1617	
1304	4006	4006	
1305	1401	1401	
1306	0700	0700	
1307	5700	JMP I TEXTM	
1310	5310	TEXTN, JMP .	

1311	4464	JMS I XMSSG	/NO INTERRUPT
1312	4543	4543	
1313	1617	1617	
1314	4011	4011	
1315	1624	1624	
1316	0522	0522	
1317	2225	2225	
1320	2024	2024	
1321	0000	0000	
1322	5710	JMP I TEXTN	
1323	5323	TEXTP, JMP .	
1324	4464	JMS I XMSSG	/LIMITS BAD
1325	4543	4543	
1326	1411	1411	
1327	1511	1511	
1330	2423	2423	
1331	4002	4002	
1332	0104	0104	
1333	0000	0000	
1334	5723	JMP I TEXTP	
1335	5335	TEXTR, JMP .	
1336	4464	JMS I XMSSG	/XXXX DIP
1337	4543	4543	
1340	6060	6060	
1341	6060	6060	
1342	4004	4004	
1343	1120	1120	
1344	0000	0000	
1345	5735	JMP I TEXTR	
1346	5346	TEXTE, JMP .	
1347	4464	JMS I XMSSG	/PASS COMPLETE
1350	4543	4543	
1351	2001	2001	
1352	2323	2323	
1353	4003	4003	
1354	1715	1715	
1355	2014	2014	
1356	0524	0524	
1357	0500	0500	
1360	5746	JMP I TEXTE	
1361	5361	TEXTF, JMP .	
1362	4464	JMS I XMSSG	/SPACE MINUS
1363	4055	4055	
1364	0000	0000	
1365	5761	JMP I TEXTF	
1366	5366	TEXTC, JMP .	
1367	4464	JMS I XMSSG	/SW NUMBER
1370	4023	4023	
1371	2740	2740	
1372	6060	6060	/SW XX
1373	4343	4343	
1374	4300	4300	
1375	5766	JMP I TEXTC	

```

*1400
/ALL NUMBERS CHECK 11 BIT
1400 5200 ALLNUM,      JMP .
1401 6032      KCC              /CLEAR TESTER
1402 7200      CLA
1403 3124      DCA CCONTB      /X=BASE NUMBER
1404 1055      TAD MODE
1405 3125      DCA CCONTC      /X+MODE
1406 4070      JMS XLOOP      /SET UP FOR LOOP
1407 6532      ADCV            /INIT CONVERSION 189 JMP TO TOXOR
1410 6531      ADSF            /WAIT FOR FLAG
1411 5210      JMP .-1         /FOR 189=JMP.+1
1412 6534      ADRB            /READ CONVERTER
1413 3046      DCA BAD        /TEMP STORAGE
1414 1046      TAD BAD
1415 7041      CIA
1416 1124      TAD CCONTB      /DATA=X
1417 7440      SZA
1420 5233      JMP .+13        /NO
1421 4366      JMS FOOL        /INC TESTER YES
1422 7200      CLA
1423 1125      TAD CCONTC
1424 1055      TAD MODE
1425 3125      DCA CCONTC
1426 1124      TAD CCONTB
1427 1055      TAD MODE
1430 7450      SNA
1431 5264      JMP BLIM        /LOOP
1432 3124      DCA CCONTB
1433 7000      NOP
1434 7200      CLA
1435 1046      TAD BAD        /DATA
1436 7041      CIA
1437 1125      TAD CCONTC      /((X+MODE)+DATA)
1440 7440      SZA
1441 5244      JMP .+3         /INC TESTER NO
1442 4534      JMS I XERNUM    /BAD ERROR YES
1443 5221      JMP .-22        /INC TEST, X, X+1
1444 7200      CLA            /CHECK FOR VOLTAGE DIP
1445 1055      TAD MODE
1446 7106      CLL RTL
1447 7041      CIA
1450 1124      TAD CCONTB      /X-MODE
1451 7041      CIA
1452 1046      TAD BAD        /X=MODE-DATA
1453 7650      SNA CLA
1454 4527      JMS I XERDIP    /ERROR VOLTAGE DIP
1455 4366      JMS FOOL        /INC TESTER
1456 1034      TAD MASKD      /CONVERSION TIME
1457 3263      DCA BLIM-1
1460 2263      ISZ BLIM-1
1461 5260      JMP .-1
1462 5470      JMP I XLOOP     /LOOP
1463 0000      0              /STALL

1464 7300      BLIM,          CLL CLA
1465 1046      TAD BAD
1466 1055      TAD MODE        /CONSTANT

```

```

1467 7420 SNL
1470 5272 JMP .+2 /CHECK MORE
1471 5277 JMP .+6 /NORMAL EXIT FOR 138
1472 1077 TAD TESTB /4000 FOR 189
1473 7440 SZA
1474 5276 JMP .+2 /ERROR
1475 7420 SNL /SKIP IF LINK=1
1476 4540 JMS I XTEXTP /ERROR LIMITS
1477 7200 CLA
1500 1110 TAD MASKF
1501 3376 DCA FOOLR
1502 3375 DCA FOOLA
1503 5600 JMP I ALLNUM /RETURN

1504 5304 ERNUM, JMP .
1505 4507 JMS I XTRXAL
1506 0124 CCONTB
1507 0342 TEXTL+3
1510 0343 TEXTL+4
1511 4535 JMS I XTEXTL /PRINT
1512 5704 JMP I ERNUM /EXIT

1513 5313 ERDIP, JMP . /FOR MONOUTICITY CHECK,
1514 4507 JMS I XTRXAL /A DIP WHICH VOLTAGE
1515 0124 CCONTB /SHOULD HAVE STAYED THE
1516 1340 TEXTR+3 /SAME OR INCREMENTED
1517 1341 TEXTR+4
1520 4541 JMS I XTEXTR
1521 5713 JMP I FRDIP

/ DATA FLAG CHECK 138E
1522 5322 DTFLAG, JMP .
1523 6532 ADCV /INITIAL CONVERSION
1524 3332 DCA .+6
1525 2332 ISZ .+5
1526 5325 JMP .-1
1527 6531 ADSF /SKIP ON FLAG
1530 4536 JMS I XTEXTM /ERROR NO FLAG
1531 5722 JMP I DTFLAG /GOOD RETURN
1532 0000 0000 /TIMER

/ INTERRUPT CHECK 138E
1533 5333 INTENT, JMP .
1534 4354 JMS CLRFLG
1535 7100 CLL
1536 6532 ADCV
1537 6001 ION /INITIAL CONVERSION
1540 3346 DCA .+6
1541 2346 ISZ .+5
1542 5341 JMP .-1
1543 6002 IOF
1544 4537 JMS I XTEXTN /ERROR NO INTERRUPT

```

```
1545 5733    JMP I INTENT
1546 0000    0
1547 7200    CLA
1550 1346    TAD .-2
1551 7650    SNA CLA          /INTERRUPT UP NO TIME DELAY
1552 4517    JMS I XTEXTG        /ERROR INTERRUPT ALWAYS UP
1553 5345    JMP .-6             /EXIT
```

/ROUTINE TO CLEAR FLAGS

```
1554 5354    CLRFLG,      JMP .
1555 6002    IOF              /I/O OFF
1556 6022    PCF              /H.S. PUNCH
1557 6042    TCF
1560 6012    RRB              /H.S. READER
1561 6072    6072          /DCF-DISPLAY
1562 6502    6502          /PLCF-PLOTTER
1563 6032    KCC              /TTY
1564 6772    MMCF           /DEC TAPE
1565 5754    JMP I CLRFLG
```

/COUNT OF TESTER INCREMENTATION

```
1566 5366    FOOL,      JMP .
1567 6034    KRS        /INC TESTER
1570 2375    ISZ FOOLA
1571 5766    JMP I FOOL
1572 2376    ISZ FOOLB
1573 5766    JMP I FOOL
1574 5264    JMP BLIM
1575 0000    FOOLA,     0
1576 7776    FOOLB,     7776        /8192 COUNT
```

AC138F	1050	LOOP	0051	TOXOR	0745
AC189	1075	MASKA	0026	TRXAL	1200
ADTEXT	0400	MASKR	0030	TYPECH	0232
ALLNUM	1400	MASKC	0032	XADTES	0131
ALOC	0365	MASKD	0034	XALLNU	0130
AUTO38	0421	MASKF	0110	XAUTO	0132
BAD	0046	MASK77	0263	XBAD	0063
BITLG	0615	MESAGE	0200	XDTFLA	0057
BLIM	1464	MODE	0055	XER	0126
BLOC	0366	MSRGHT	0231	XERDIP	0127
BWORD	0075	MTP	0256	XERNUM	0134
CCONTA	0123	MUX39E	0732	XERR	0072
CCONTB	0124	M2	0270	XHALT	0104
CCONTC	0125	M3	0266	XINC	0103
CHAN	0074	M40	0264	XINSTA	0061
CLRFLG	1554	PTFX	0112	XINSTB	0062
COMPAR	0471	SPL	0710	XINTEN	0060
CON1	0047	START	0600	XI189	0056
CTFMA	0120	STDATA	0453	XLOOP	0070
CTFM	0121	STSW	0101	XMSSR	0064
CTFML	0122	SWITCH	0142	XMUX39	0105
Q212	0267	SWTEST	0020	XOR	0351
Q215	0271	TBUFF	0042	XSPL	0102
Q245	0272	TC	1260	XSTDA T	0111
Q340	0265	TEMPF	0037	XTFXTA	0065
DATA	0040	TEM1	0050	XTFXTB	0066
DTFLG	1522	TESTA	0076	XTFXTC	0067
FR	0273	TESTB	0077	XTFXTD	0115
FRDI	1513	TESTC	0100	XTFXTF	0116
FRNUM	1504	TESTL1	0044	XTFXTG	0117
FLAG	0106	TESTL2	0045	XTFXTK	0133
FOOL	1566	TEXTA	0672	XTFXTL	0135
FOOLA	1575	TEXTB	0703	XTFXTM	0136
FOOLB	1576	TEXTC	1366	XTFXTN	0137
HALT	1261	TEXTF	1346	XTFXTP	0140
HOKEFP	0432	TEXTF	1361	XTFXTR	0141
INRUFF	0041	TEXTG	0717	XTOXOR	0143
INC	0571	TEXTK	0321	XTRXAL	0107
INLL	0043	TEXTL	0337	XXOR	0144
INSTA	0567	TEXTM	1300		
INSTR	0547	TEXTN	1310		
INTENT	1533	TEXTP	1323		
I189	0631	TEXTR	1335		



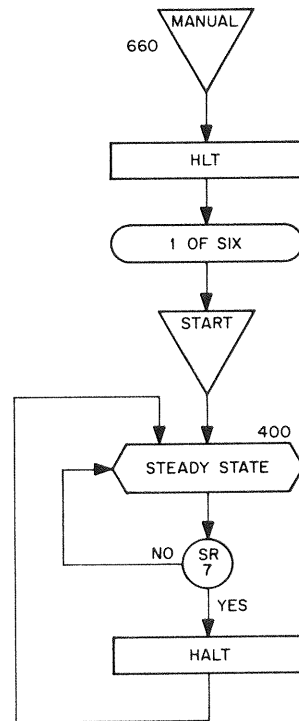
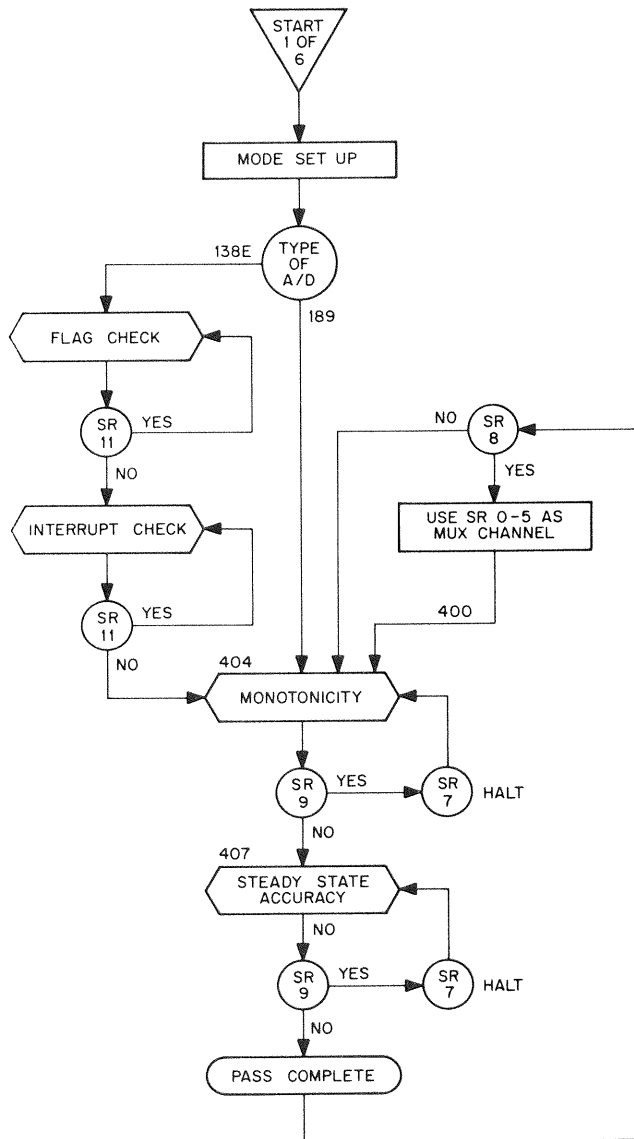
11 DIAGRAMS

11.1 Flow Charts

There are three flow charts using the factory built tester for automatic checkout.

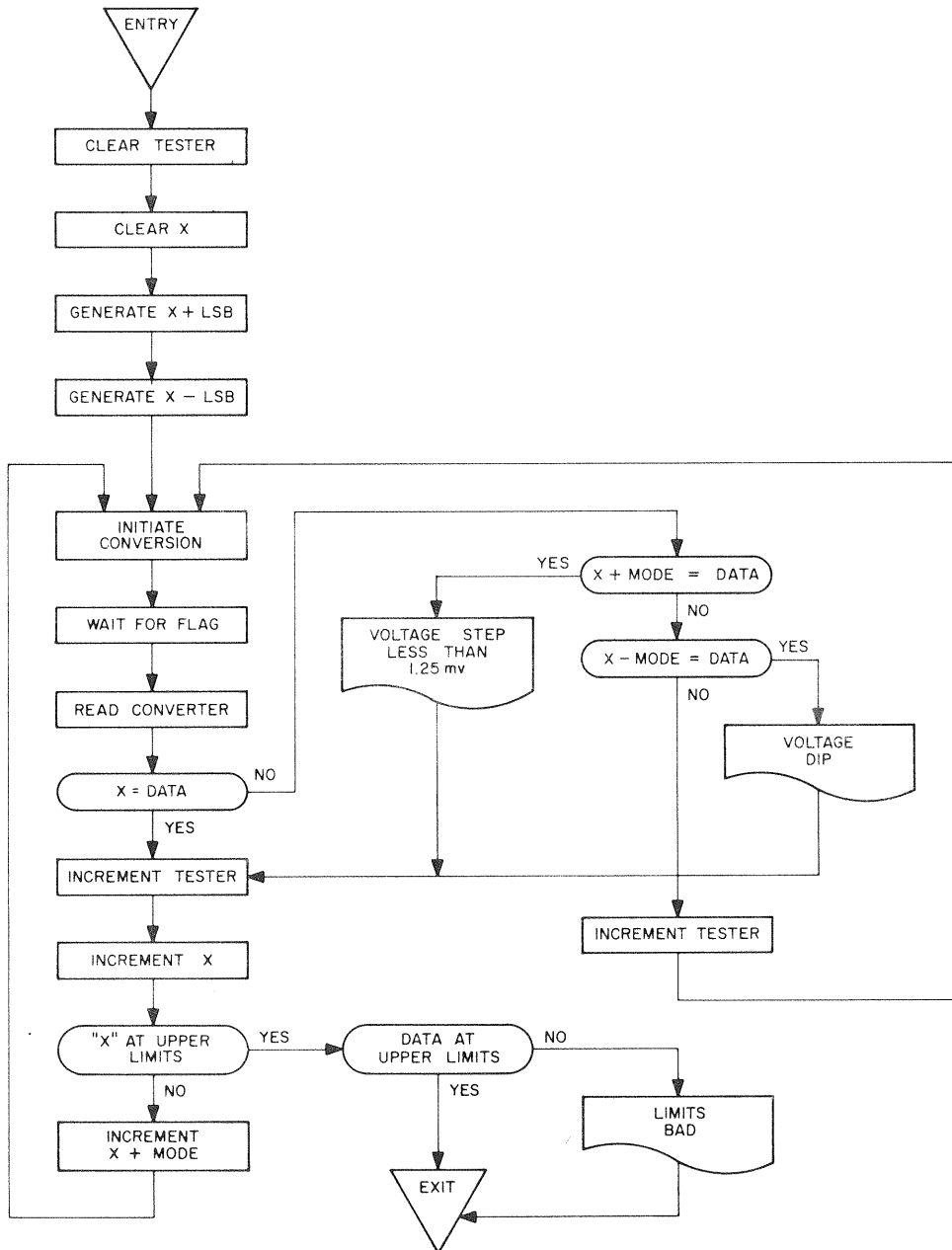
11.1.1 Analog-to-Digital Converter Test

MODE	138E	189
10 Bit	613	626
11 Bit	611	622
12 Bit	600	616



Please Note: SR 6 ⇒ 1 Remove all printouts.

11.1.2 Monotonicity\*



\*All states exits in the correct order and never dip back at any point (A/D Conversion Handbook E5100 7/64 p11).

11.1.3 Steady State Accuracy

