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

*Automatic A/D Converter Tester #7605039-0

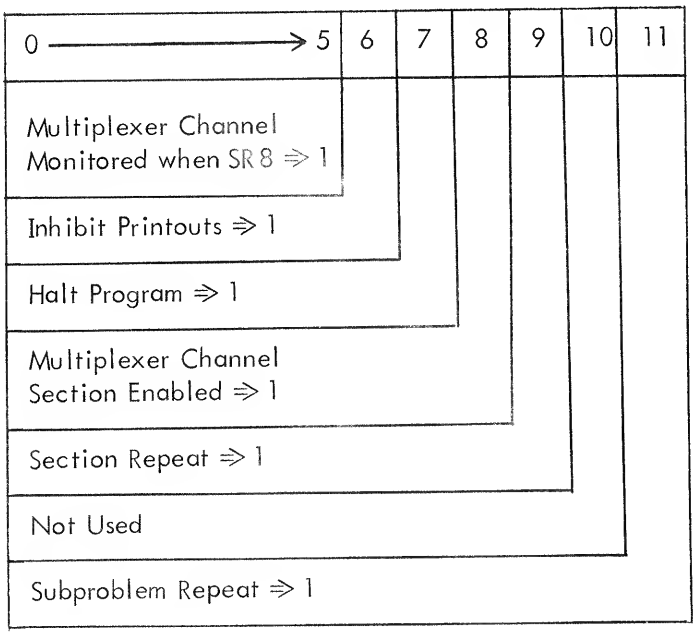
4.2.3 Multiplexer Test - For an automatic test of all switches for the multiplexer, go to one of the six initial start-up addresses, halt, then go to address 1000 to start.

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

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*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 convered 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 relative 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 ±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-Bit Word (Mode) = $1_{(8)}$

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

10-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 }
1376 }  3 Stating Values
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
```

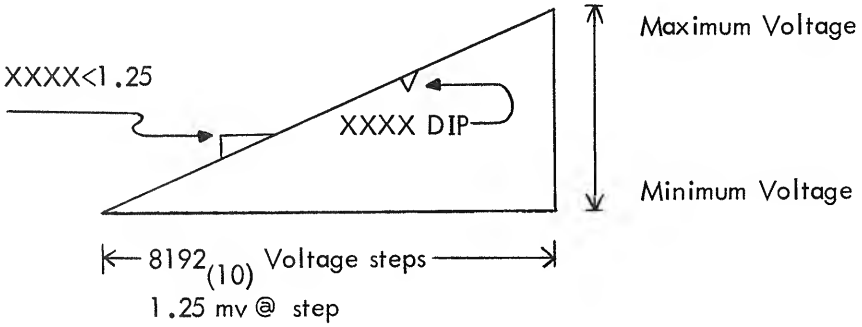
The reference word is not made the center value of a three stating condition, therefore it is possible for one of the values to show as occuring 00 times. In case (c) it was the value above the reference value that was not found.

1372		
1374	The third state	3 Stating Values
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

```
                    /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  XDTFLA,  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,   MESAGE
0065  0672  XTEXTA,  TEXTA                 /3 STATES
0066  0703  XTEXTB,  TEXTB                 /CR AND LF
0067  1366  XTEXTC,  TEXTC                 /XX DIP
```

```
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  MESAGE,     0
0201  7604    LAS                /CHECK FOR PRINT
0202  0025    AND SWTEST+5       /XX4X
0203  7640    SZA CLA
0204  5206    JMP .+2
```

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

0216  3010    DCA 10                /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 MESAGE+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
```

```
                /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 ER

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 .                 /EXECLUSIVE 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
```

```
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

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

                /TEXT MULTIPLIER

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           /XOXO
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 FOOLB
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 ERDIP


            /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,      77776      /8192 COUNT
```

```
@AC138F  1050
AC189    1075
ADTE.T   0400
ALLNUM   1400
ALOC     0365
AUTO38   0421
BAD      0046
BITLG    0615
BLIM     1464
BLOC     0366
BWORD    0075
CCONTA   0123
CCONTB   0124
CCONTC   0125
CHAN     0074
CLRFLG   1554
COMPAR   0471
CON1     0047
CTEMA    0120
CTEMB    0121
CTEMC    0122
C212     0267
C215     0271
C245     0272
C340     0265
DATA     0040
DTFL.G   1522
ER       0273
ERDIP    1513
ERNUM    1504
FLAG     0106
FOOL     1566
FOOLA    1575
FOOLB    1576
HALT     1261
HOKEFP   0432
INBUFF   0041
INC      0571
INLL     0043
INSTA    0567
INSTB    0547
INTENT   1533
I189     0631
LOOP     0051
MASKA    0026
MASKB    0030
MASKC    0032
MASKD    0034
MASKE    0110
MASK77   0263
MESAGE   0200
MODE     0055
MSRGHT   0231
MTP      0256
MUX39E   0732
M2       0270
M3       0266
M40      0264
PTEX     0112
SPL      0710
START    0600
STDATA   0453
STSW     0101
SWITCH   0142
SWTEST   0020
TBUFF    0042
TC       1260
TEMPE    0037
TEM1     0050
TESTA    0076
TESTB    0077
TESTC    0100
TESTL1   0044
TESTL2   0045
TEXTA    0672
TEXTB    0703
TEXTC    1366
TEXTE    1346
TEXTF    1361
TEXTG    0717
TEXTK    0321
TEXTL    0337
TEXTM    1300
TEXTN    1310
TEXTP    1323
TEXTR    1335
TOXOR    0745
TRXAL    1200
TYPECH   0232
XADTES   0131
XALLNU   0130
XAUTO    0132
XBAD     0063
XDTFLA   0057
XER      0126
XERDIP   0127
XERNUM   0134
XERR     0072
XHALT    0104
XINC     0103
XINSTA   0061
XINSTB   0062
XINTEN   0060
XI189    0056
XLOOP    0070
XMSSG    0064
XMUX39   0105
XOR      0351
XSPL     0102
XSTDAT   0111
XTEXTA   0065
XTEXTB   0066
XTEXTC   0067
XTEXTE   0115
XTEXTF   0116
XTEXTG   0117
XTEXTK   0133
XTEXTL   0135
XTEXTM   0136
XTEXTN   0137
XTEXTP   0140
XTEXTR   0141
XTOXOR   0143
XTRXAL   0107
XXOR     0144
```

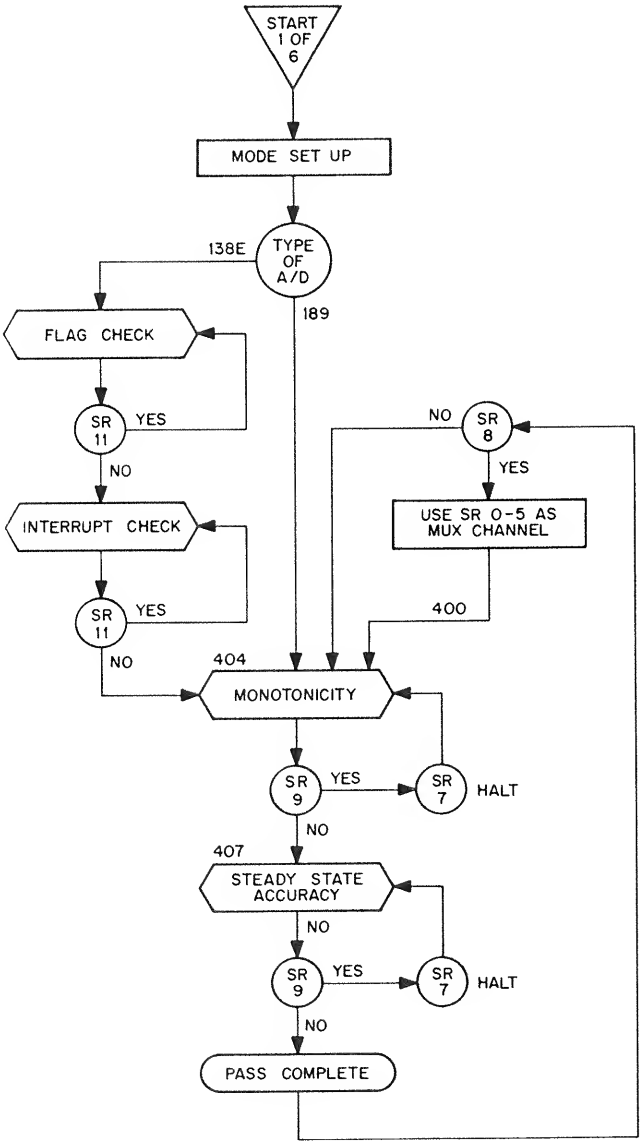
11 DIAGRAMS

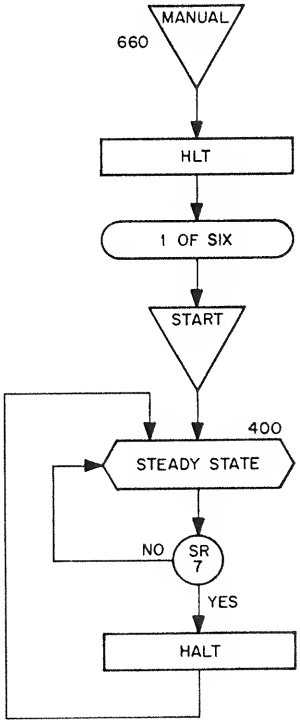
11.1 Flow Charts

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

11.1.1 Analog-to-Digital Converter Test

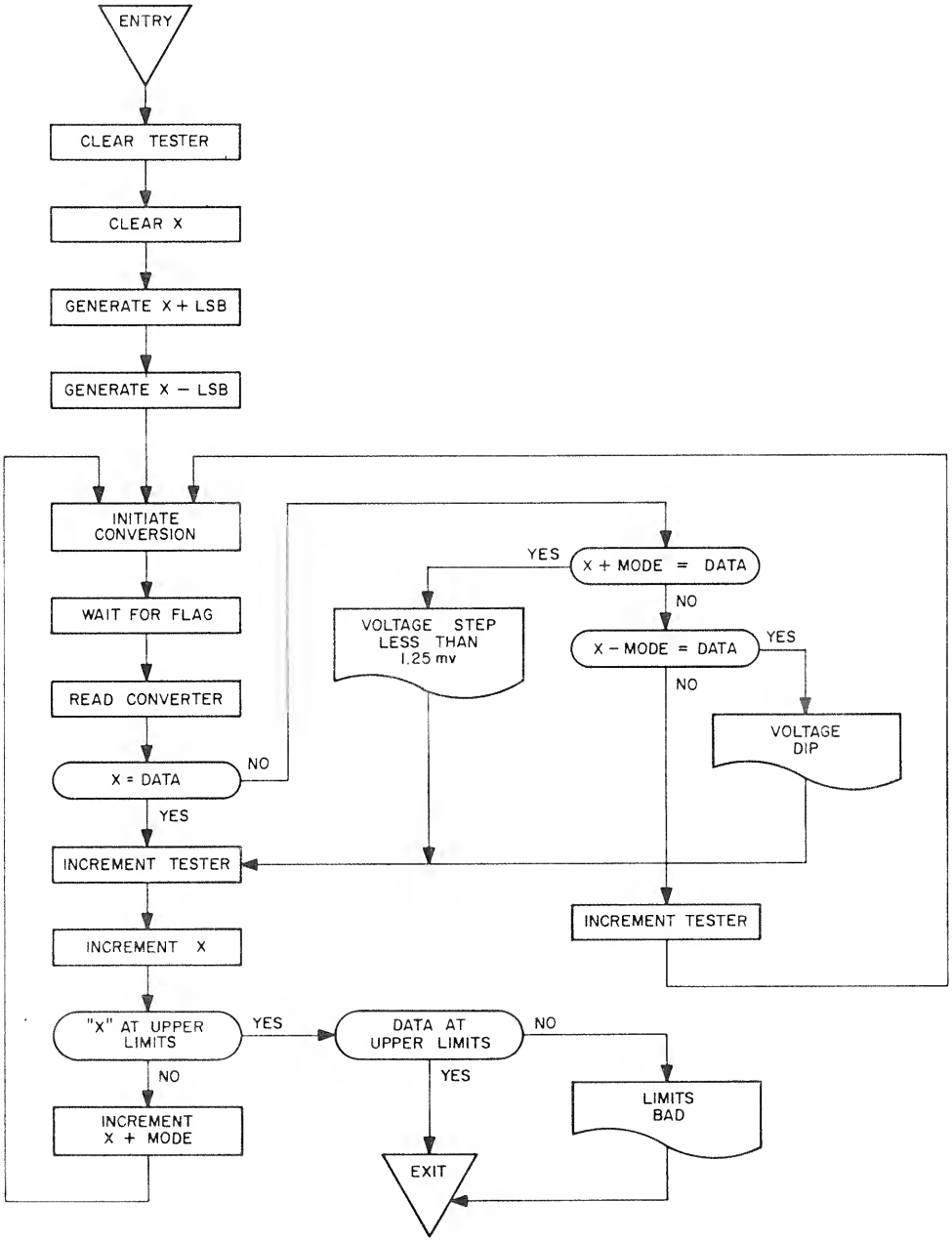
MODE	138E	189
10 Bit	613	626
11 Bit	611	622
12 Bit	600	616





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