1. IDENTIFICATION

1.1 PDP-8 Maindec 826-B

1.2 680 5-Bit Character Exerciser

1.3 November 17, 1965

2. ABSTRACT

The 680 5-Bit Character Exerciser program further verifies correct operation of the 680 Data Communications System. This test assumes that the Teletype lines are full duplex. However, if the line outputs are jumpered to the line inputs, the test verifies that the input characters are received as transmitted.

3. REQUIREMENTS

3.1 Storage

3.1.1 Exerciser Program

	Address 0
Concurrent Output Test	0200_8 to 0377_8
Output Data Table	0400_8 to 0535_8
Concurrent Input Test	0600_8 to 0616_8
Output Switch Register Routine	1000_8 to 1074_8
Output Buffer	2200 to 2377_8
Input Buffer	2400 to 2577_8
Interrupt Routine	0001 to 0004

3.1.2 Character Assembly Subroutines (List of Items)

TT5BGN	Start of Subroutines	5200_8 to 5577_8
T5IN	TTI Area	5600_8 to 6400_8
T5IBF	Input Buffer	7200_8 to 7577_8
T5OBF	Output Buffer	6600_8 to 6777_8
T5OBF2	Second Output Buffer	7000_8 to 7177_8
TT5PG0	Page 0 Constants	0145_8 to 0176_8
TTCHAR	Character Register	0177_8
T5AX1	Autoindex	10
T5AX2	Autoindex	11
T5AX3	Autoindex	12
T5AX4	Autoindex	13

3.2 Subprograms and/or Subroutines

Digital-8-35-S-A
680 5-bit Character Assembly Subroutines

3.3 Equipment

Minimum Configuration PDP-8
680 DCS hardware (Including a 50 or 75 Baud Clock)

3.4 Miscellaneous

The 50 or 75 Baud Clock in clock 1.

4. USAGE

4.1 Loading

4.1.1 If the Binary loader beginning at address 7777 is in memory, go to Section 4.1.2. Otherwise the RIM Loader and/or the Binary Loader must be loaded into memory.

4.1.2 The 6805-Bit Character Exerciser may now be loaded into memory as follows:

Set 7777_8 in the SWITCH REGISTER

Press LOAD ADDRESS

Place the Character Exerciser in the keyboard reader

Press START

Engage the keyboard reader

4.3 Switch Settings (See Section 4.4)

4.4 Start up and/or Entry

4.4.1 Concurrent Output Test

Set the SWITCH REGISTER to 0200

Press the LOAD ADDRESS key

Set the SWITCH REGISTER equal to the lowest line number to be tested.

Press START; the processor halts at address 0202.

Set the SWITCH REGISTER equal to the number of lines to be tested.

Press CONTINUE; the program outputs a fixed message on all the lines selected.

4.4.2 Concurrent Input Test

Set the SWITCH REGISTER to 0600.

Press the LOAD ADDRESS key.

Press START; the program scans 128 lines for input and retransmits characters on the same line as the one in which they are received.

Output SWITCH REGISTER test

Set the SWITCH REGISTER to 1000.

Press the LOAD ADDRESS key.

Set the SWITCH REGISTER to the line number to be tested.

Press START; the processor halts at address 1002.

Set SWITCH REGISTER bits 7 through 11 equal to the character to be transmitted, and SW0 as follows:

SW0-down: Do not test for input

SW0-up: Wait for input and verify that it is the same character as is transmitted. (See the end of Section 4.4.1.)

Press CONTINUE; the program transmits a carriage return-line feed, the contents of AC switches 64 times, and then repeats.

Note that since the input is two characters behind the output, (due to double buffering of the Character Assembly Subroutines) SW0 may not be changed from 0 to a 1 once the program is running. It may, however, be changed from a 1 to a 0 and switches 7 through 11 may be altered at any time.

4.5 Errors in Usage

Hardware malfunctions detected by the program result in a processor halt. The following is a list of these error halts and their meanings:

4.5.1 Address 0002 Not Clock Interrupt

Either an interrupt was received from a device other than Teletype clock 1, or the IOT 6421 did not skip after an interrupt from clock 1.

4.5.2 Address 0307 Data Error

The processor halts with a line number displayed in the AC indicating that a data error has occurred on the line. Press CONTINUE; the processor halts at address 0312 with the character that should have been received in the AC. Press CONTINUE again, and the processor halts at address 0315 with the character that was received in the AC.

4.5.3 Address 1055 Data Error (Output AC Switches Routine)

Processor halts with the character transmitted in the AC. This could be a carriage return, a line feed, or the code contained in the SWITCH REGISTER. Press CONTINUE, and the processor halts at address 1061 with the character that was received displayed in the AC.

4.5.4 Detection of an Open Input Line

If the data error halt at address 0312 is consistently executed with a specific line number and the character received is always 0, it indicates that the input line is in a constant "SPACE" or open line state.

4.5.5 Detection of a Constant "MARK"

The 680 Character Exerciser was written with the assumption that the Teletype lines being tested are full duplex. Also, the program assumes that any input received during the concurrent output test is due to the fact that the line outputs are tied to the line inputs. Therefore, if there is no input on a line or any of the lines the program does not consider it an error. Assuming the test is operating with inputs tied to outputs, the only way to be sure that a line is transmitting and receiving is to open the input line in order to force a data error.

Note that this procedure is likely to show up any errors in translating line numbers; i.e., input line 17 is opened and the processor does not halt. The line then is closed again and an error is indicated, for example, on line 37. The malfunction is probably in the decoding of line 17.

4.6 Recovery From Such Errors

Pressing CONTINUE causes the program to proceed. It is possible that an error halt will leave some of the output lines in a "SPACE" condition. If this happens, any Teletypes that are tied to these outputs will run free until the program continues. Also, in the process of opening lines to test for transmitting and receiving, it is possible to get the input of a line out of sequence with the output. In this case, it is necessary to restart the test.

5. RESTRICTIONS

The Character Assembly Subroutines scan the lines in even multiples of eight lines. Therefore, it is possible that an error could be indicated on a line or lines that have not been selected to be run, e.g., in the Output Switch Register Routine, if line 1 is selected to be run, the inputs of lines 2, 3, 4, 5, 6, 7, and 10_8 should be placed in the "MARK" state.

6. DESCRIPTION

6.1 Discussion

6.1.1 General

The 680 5-Bit Character Exerciser transmits and/or receives 5-bit coded Teletype data at the line speed of Teletype clock 1 and will verify correct operation of the 680 DCS hardware. The program allows parameters to exercise up to 128 lines and includes three test modes: Concurrent Output, Concurrent Input, and Output the Switch Register.

6.1.2 Test Descriptions

6.1.2.1 Concurrent Output Test

The Concurrent Output Test accepts parameters to transmit on from 1 through 128 lines. The program assumes that all the lines selected are full duplex and that any input is due to an output line jumpered to an input line.

The following message is transmitted on all lines selected:

THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG
0123456789 -?:$!&#'().,;/"
RYRYRY

If input is received on any of the lines selected, the program verifies that the characters received are received in the same order they are transmitted. Also, since the input is tested almost independently of the output, it is possible to jumper input lines to output lines in any configuration that is desired, including and/or other than 1 for 1.

6.1.2.2 Concurrent Input Test

The Concurrent Input Test initializes to scan all 128 lines for input. When a character is received on a line, the program transmits the character received on the same line.

6.1.2.3 Output The Switch Register Routine

This Routine transmits the code contained in SWITCH REGISTER bits 7 through 11 on the line specified by the contents of the SWITCH REGISTER when the routine is started. The program transmits a carriage return, line feed, the contents of the SWITCH REGISTER 64 times, and then repeats. If SWITCH REGISTER bit 0 is a 1, the program transmits a character, waits for it to be input and then verifies that the output and input are equal. Since the input is two characters behind the output (due to the double buffering of output characters in the character assembly subroutines), the compare mode must be selected at the time the processor halts at address 1002.

7. METHODS (Not Applicable)

8. FORMAT (Not Applicable)

9. EXECUTION TIME (Not Applicable)

10. PROGRAM

10.4 Program Listing

```
                PAUSE

                /TYPE 680 TELETYPE LINE MULTIPLEXER  5 BIT
                /EXERCISER
                /KFN   10/15/65

                /START AT 200
                /WITH STARTING LINE NUMBER IN SWITCHES
                /COMPUTER WILL HALT
                /SET SWITCHES = TO NUMBER OF LINES
                /CONTINUE
                /PROGRAM WILL RUN UNTIL AN ERROR
                /IS DETECTED OR UNTIL STOP

                /INTERRUPT ROUTINE

                *0001
0001  6421  INRUPT,     T5SKP              /WAS IT 5 BIT CLOCK
0002  7402       HLT                /NO, UNKNOWN INTERRUPT
0003  5404       JMP I .+1                  /YES, PROCESS INTERRUPT
0004  5200       T5DIS              /TT5BGN
                *200
0200  7604  DCSTST,     CLA OSR            /GET STARTING LINE
0201  3230       DCA STRLIN         /SAVE IT
0202  7402       HLT                /HALT, WAIT NUMBER OF LINES
0203  7604       CLA OSR            /GET NO OF LINES
0204  3331       DCA NUMLIN         /SAVE IT
0205  1331       TAD NUMLIN         /NO LINES
0206  7041       CIA                /2'S COMPLEMENT
0207  3332       DCA LINDEX         /SAVE FOR COUNTING
0210  1332       TAD LINDEX         /SET UP
0211  3345       DCA NDEX                   /INDICES
0212  1333       TAD OUTDEX         /FOR INITIAL
0213  1230       TAD STRLIN         /SET UP OF
0214  3011       DCA Z 11                   /INPUT AND
0215  1335       TAD INPDEX         /OUTPUT BUFFERS
0216  1230       TAD STRLIN
0217  3012       DCA Z 12
0220  1337  DCBFLP,      TAD CHARAC         /ADDRESS OF CHAR TABLE
0221  3411       DCA I Z 11         /TO OUTPUT BUFFER
0222  1337       TAD CHARAC         /ADDRESS TO COMPARE
0223  3412       DCA I Z 12         /CHAR TO INPUT BUFFER
0224  2345       ISZ NDEX                   /GOT ALL LINES
0225  5220       JMP DCBFLP         /NO
0226  1331       TAD NUMLIN         /SET NO OF LINES IN AC
0227  4552       T5INIT             /INITIALIZE TTY
0230  0000  STRLIN,      0                  /STARTING LINE NUMBER
```

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0231  6424        TT5ON             /TURN CLOCK ON
0232  6001        ION               /TURN INTERRUPTS ON
0233  7200        CLA
0234  1230        TAD STRLIN        /FORM START OF
0235  1334        TAD OUTDFX+1      /OUTPUT BUFFER
0236  3340        DCA CUROUT
0237  1230        TAD STRLIN        /GET FIRST LINE NO.
0240  3341        DCA CURLIN
0241  1332        TAD LINDFX
0242  3345        DCA NDEX

0243  1740  OTLOOP,      TAD I CUROUT     /GET POINTER FOR NEXT OUTPUT
0244  3342        DCA SAVCUR
0245  1742        TAD I SAVCUR      /GET NEXT OUTPUT CHARACTER
0246  3177        DCA Z TTCHAR
0247  1341        TAD CURLIN        /GET LINE NUMBER
0250  4550        T5SOF             /CHECK FOR FREE OUTPUT
0251  7410        SKP               /OUTPUT NOT FREE
0252  2740        ISZ I CUROUT      /ADD 1 TO CHARACTER POINTER
0253  1740        TAD I CUROUT
0254  7041        CIA               /HAS CURRENT
0255  1343        TAD LSTCHR        /LINE REACHED
0256  7440        SZA               /THE END OF OUTPUT
0257  5262        JMP .+3           /NO
0260  1337        TAD CHARAC        /YES RESET POINTER
0261  3740        DCA I CUROUT      /TO FIRST CHARACTER
0262  2340        ISZ CUROUT        /ADVANCE TO NEXT LINE
0263  2341        ISZ CURLIN        /ADVANCE TO NEXT LINE
0264  7200        CLA               /CLEAR FOR TAD
0265  2345        ISZ NDEX                  /TESTED ALL LINED FOR FREE
0266  5243        JMP OTLOOP        /NO, TRY NEXT LINE
0267  4551  INLOOP,      T5SIR             /ANY INPUT AVAILABLE
0270  5233        JMP STRLIN+3      /NO, OUTPUT AGAIN
0271  3341        DCA CURLIN        /YES, SAVE LINE NO.
0272  1341        TAD CURLIN
0273  1336        TAD INPDFX+1      /FIND INPUT POINTER
0274  3340        DCA CUROUT        /FOR THE LINE
0275  1740        TAD I CUROUT      /GET INPUT POINTER
0276  3342        DCA SAVCUR
0277  1177        TAD TTCHAR        /GET NEXT INPUT CHARACTER
0300  0344        AND LSTCHR+1      /37
0301  7041        CIA
0302  1742        TAD I SAVCUR      /CHARACTER INPUT
0303  7450        SNA               /EQUAL CHARACTER EXPECTED
0304  5317        JMP INCINP        /YES, INCREMENT POINTER
0305  7200        CLA
0306  1341        TAD CURLIN        /LINE NUMBER TO AC
0307  7402        HLT               /HALT
0310  7200        CLA
0311  1742        TAD I SAVCUR      /CHARACTER EXPECTED TO AC
0312  7402        HLT               /HALT
0313  7200        CLA
0314  1177        TAD Z TTCHAR      /CHARACTER RECEIVED
0315  0344        AND LSTCHR+1
0316  7402        HLT               /HALT
0317  2740  INCINP,      ISZ I CUROUT     /ADVANCE INPUT POINTER
0320  7200        CLA
0321  1740        TAD I CUROUT      /GET INCREMENTED POINTER
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0322  7041       CIA
0323  1343       TAD LSTCHR       /LINE AT END OF
0324  7440       SZA              /INPUT CHARACTERS
0325  5267       JMP INLOOP       /NO, TEST FOR MORE INPUT
0326  1337       TAD CHARAC       /RESET INPUT POINTER
0327  3740       DCA I CUROUT     /TO FIRST CHARACTER
0330  5267       JMP INLOOP       /TEST FOR MORE INPUT

0331  0000  NUMLIN,      0                /NUMBER OF LINES
0332  0000  LINDEX,      0                /2'S COMPLEMENT NO OF LINES
0333  2177  OUTDEX,      BUFFR-1          /FOR FILLING OUTPUT BUFFER
0334  2200       BUFFR            /FOR CHECKING OUTPUT BUFFER
0335  2377  INPDEX,      INBUFR-1                 /FOR FILLING INPUT BUFFER
0336  2400       INBUFR
0337  0400  CHARAC,      CODES            /START OF 5 BIT CODES
0340  0000  CUROUT,      0                /TEMP STORAGE BUFFER POINTER
0341  0000  CURLIN,      0                /TEMP STORAGE CURRENT LINE NO.
0342  0000  SAVCUR,      0                /TEMP STORAGE CHARACTER POINTER
0343  0527  LSTCHR,      NDCOD+1          /FOR DETECTING END OF CHARACTERS
0344  0037       37               /FOR ANDING TTCHAR
0345  0000  NDEX,        0                /FOR COUTING

            BUFFR=2200
            INBUFR=2400
            /5 BIT CODES OUTPUT BY DCSTST
            *400
0400  0010  CODES,       10               /CARRIAGE RETURN
0401  0002       02               /LINE FEED
0402  0002       02               /LINE FEED
0403  0037       37               /LETTERS
0404  0020       20               /T
0405  0024       24               /H
0406  0001       01               /E
0407  0004       04               /SPACE
0410  0027       27               /Q
0411  0007       07               /U
0412  0006       06               /I
0413  0016       16               /C
0414  0017       17               /K
0415  0004       04               /SPACE
0416  0031       31               /B
0417  0012       12               /R
0420  0030       30               /O
0421  0023       23               /W
0422  0014       14               /N
0423  0004       04               /SPACE
0424  0015       15               /F
0425  0030       30               /O
0426  0035       35               /X
0427  0004       04               /SPACE
0433  0013       13               /J
0431  0007       07               /U
0432  0034       34               /M
0433  0026       26               /P
0434  0005       05               /S
0435  0004       04               /SPACE
0436  0030       30               /O
```

```
0437  0036        36                /V
0440  0001        01                /E
0441  0012        12                /R
0442  0004        04                /SPACE
0443  0020        20                /T
0444  0024        24                /H
0445  0001        01                /E
0446  0004        04                /SPACE
0447  0022        22                /L
0450  0003        03                /A
0451  0021        21                /Z
0452  0025        25                /Y
0453  0004        04                /SPACE
0454  0011        11                /D
0455  0030        30                /O
0456  0032        32                /G
0457  0010        10                /CARRIAGE RETURN
0460  0002        02                /LINE FEED
0461  0033        33                /FIGURES
0462  0026        26                /0
0463  0027        27                /1
0464  0023        23                /2
0465  0001        01                /3
0466  0012        12                /4
0467  0020        20                /5
0470  0025        25                /6
0471  0007        07                /7
0472  0006        06                /9
0473  0030        30                /9
0474  0004        04                /SPACE
0475  0003        03                /MINUS
0476  0031        31                /QUESTION
0477  0016        16                /COLON
0500  0011        11                /DOLLAR
0501  0015        15                /EXCLAMATION
0502  0032        32                /AND
0503  0024        24                /NUMBER SIGN
0504  0013        13                /APOSTHROPHE
0505  0017        17                /LEFT PARENS
0506  0022        22                /RIGHT PARENS
0507  0034        34                /PERIOD
0510  0014        14                /COMMA
0511  0036        36                /SEMI COLON
0512  0035        35                /SLASH
0513  0021        21                /QUOTES
0514  0010        10                /CARRIAGE RETURN
0515  0002        02                /LINE FEED
0516  0037        37                /LETTERS
0517  0012        12                /R
0520  0025        25                /Y
0521  0012        12                /R
0522  0025        25                /Y
0523  0012        12                /R
0524  0025        25                /Y
0525  0012        12                /R
0526  0025  NDCOD,      25                /Y
```

```
                /CHARACTER ECHO
                /START AT 600
                /PROGRAM INITIALIZES FOR 128 LINES
                /PROGRAM WAITS FOR INPUTS
                /TRANSMITS
                /THE CHARACTERS RECEIVED
                /THEN WAITS FOR MORE INPUTS
                /PROGRAM RUNS UNTIL "STOP"


                /ECHO
                /INPUT CHARACTERS
                /THEN OUTPUT THEM

                *600
0600  7200  ECHOTS,     CLA             /GET LINE NUMBER
0601  1216      TAD ONE28               /AC=128
0602  4552      T5INIT          /SETUP FOR 128 LINES
0603  0000  ECHLIN,     0               /LINE NUMBER  0 STARTING LINE
0604  6424      TT5ON           /CLOCK ON
0605  6001      ION             /ENABLE INTERRUPTS
0606  4551      T5SIR           /SKIP IF INPUT
0607  5206      JMP .-1         /INPUT NOT READY, WAIT
0610  3215      DCA ECHDEX      /SAVE LINE NUMBER
0611  1215      TAD ECHDEX      /GET LINE NUMBER
0612  4550      T5SOF           /OUTPUT
0613  5211      JMP .-2         /NOT FREE TRY AGAIN
0614  5206      JMP ECHLIN+3    /WAIT MORE INPUT
0615  0000  ECHDEX,     0

0616  0200  ONE28,      0200
                /TRANSMIT AC SWITCHES
                /START AT 1000
                /WITH SWITCHES = LINE NUMBER
                /COMPUTER WILL HALT
                /SW0 = 0 COMPUTER WILL NOT COMPARE INPUT
                /SW0 = 1 COMPUTER COMPARES INPUT AGAINST OUTPUT
                /SW7 TO SW11 = CHARACTER TRANSMITTED
                /SW0 MAY NOT BE ALTERED ONCE RUNNING
                /SW7 TO SW11 MAY BE ALTERED
                /PROGRAM TRANSMITS CARRIAGE RETURN/LINE FEED
                /THE SW7 TO SW11 64 TIMES
                /THEN CARRIAGE RETURN LINE FEED/64 CHARACTERS
                /PROGRAM RUNS UNTIL "STOP"

                /TRANSMIT AC SWITCHES
                *1000
1000  7604  TRANSR,     CLA OSR         /GET LINE NO
1001  3205      DCA TRALIN      /T5INIT+1
1002  7402      HLT             /WAIT FOR CHARACTER
1003  7001      IAC             /AC=NO OF LINES (1)
1004  4552      T5INIT          /INITIALIZE TTY ROUTINES
1005  0000  TRALIN,     0               /LINE NUMBER
1006  6424      TT5ON           /TURN CLOCK ON
1007  6001      ION             /ENABLE INTERRUPTS
1010  1264      TAD K64         /-64
1011  3266      DCA TRADEX      /FOR COUNTING
1012  1267      TAD TRADEX+1    /CARRIAGE RETURN
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```
1013  3271        DCA TRACHR        /OUTPUT CARRIAGE RETURN
1014  4227        JMS TRAOUT        /OUTPUT
1015  1270        TAD TRADEX+2      /LINE FEED
1016  3271        DCA TRACHR        /OUTPUT CHARACTERS
1017  4227        JMS TRAOUT        /OUTPUT
1020  7604        CLA OSR           /GET CHARACTER IN SWITCHES
1021  0265        AND THREE7        /CLEAR ALL BUT LWR 5
1022  3271        DCA TRACHR        /OUTPUT CHARACTER
1023  4227        JMS TRAOUT        /OUTPUT
1024  2266        ISZ TRADEX        /OUTPUT 64 CHARACTERS
1025  5220        JMP .-5           /TEST SWITCHES AGAIN
1026  5210        JMP TRALIN+3      /OUTPUT CAR. RET./LINE FEED
1027  5227  TRAOUT,     JMP .
1030  7200        CLA
1031  1271        TAD TRACHR        /GET OUTPUT CHARACTER
1032  3177        DCA TTCHAR        /FOR OUTPUTTING
1033  1205        TAD TRALIN        /LINE NUMBER
1034  4550        T5SOF
1035  5230        JMP .-5           /OUTPUT NOT FREE, TRY AGAIN
1036  7604  TRASW0,     CLA OSR           /GET SWITCHES
1037  7004        RAL               /BIT 0 TO LINK
1040  7620        SNL CLA           /0 SET
1041  5627        JMP I TRAOUT      /NO, EXIT

1042  4551  TRAWAT,     T5SIR             /SKIP IF INPUT
1043  5242        JMP .-1           /NO INPUT, TEST SW0
1044  7200        CLA
1045  1177        TAD TTCHAR        /GET CHARACTER
1046  0265        AND THREE7        /CLEAR STOP BIT
1047  7041        CMA IAC
1050  1271        TAD TRACHR        /CHARACTER RECEIVED=SENT
1051  7450        SNA
1052  5627        JMP I TRAOUT      /EXIT
1053  7200        CLA
1054  1271        TAD TRACHR              /CHARACTER SENT
1055  7402        HLT               /HALT
1056  7200        CLA
1057  1177        TAD TTCHAR              /CHARACTER RECEIVED
1060  0265        AND THREE7              /TO LAST 5 BITS
1061  7402        HLT               /HLT
1062  7200        CLA
1063  5627        JMP I TRAOUT      /EXIT

1064  7700  K64,        7700              /-64
1065  0037  THREE7,     37                /FOR ANDING
1066  0000  TRADEX,     0                 /FOR COUNTING
1067  0010        10                /CARRIAGE RETURN
1070  0002        02                /LINE FEED
1071  0000  TRACHR,     0                 /CHARACTER STORAGE
            /TYPE 680 TELETYPE LINE MULTIPLEXER
            /CHARACTER ASSEMBLY ROUTINE
            /LMH  910/15/65  5 BIT

            TTI=6402              /TELETYPE INPUT COMMAND
            TTO=6404              /TELETYPE OUTPUT COMMAND
            TTCL=6411             /CLEAR LINE REGISTER
            TTRL=6414             /READ LINE REGISTER
            TTSL=6412             /SET LINE REGISTER, CLR AC
```

```
                TT5ON=6424              /TURN CLOCK ON
                TT5OFF=6422             /TURN CLOCK OFF
                T5SKP=6421              /SKIP ON CLOCK FLAG
                TTINCR=6401             /INCREMENT LINE REGISTER

                /680 LINE MULTIPLEXER
                /LIST OF ITEMS
                T5IBF=7200
                T5OBF2=7000
                T5OBF=6600
                T5IN=5600
                TT5PG0=145
                T5AX1=10
                T5AX2=11
                T5AX3=12
                T5AX4=13
                TT5BGN=5200
                TTCHAR=177

                *TT5PG0
0145  0000    T5INFL,   0             /INPUT READY FLAG
0146  7177    T5RFK,    T5IBF-1       /TO RESET INPUT BUFFER POINTER
0147  0000    T5NL,     0             /-NUMBER OF LINES
0150  5400    T5SOUT,   T5OUTS        /SKIP IF OUTPUT FREE
0151  5423    T5SIN,    T5INS         /SKIP IF INPUT READY
0152  5447    T5GO,     T5GOS         /INITIALIZE ROUTINE
0153  6600    T5OUTK,   T5OBF         /POINTER TO 1ST OUTPUT BUFFER
0154  7774    T5CNT1,   -4            /HOLDS MAJOR LOOP COUNTER
0155  0000    T5CNT2,   0             /MINOR LOOP COUNTER
0156  0000    T5CNT3,   0             /COUNTER FOR INPUT BUFFER
0157  0177    T5K10,    177           /FOR ANDING
0160  7000    T5K36,    T5OBF2        /2ND OUTPUT BUFFER
0161  0000    T5CNT5,   0             /OUTPUT COUNTER
0162  0000    T5CNT6,   0             /7 BIT COUNTER
0163  7770    T5K2,       -10               /TO RESET BIT COUNTER
0164  5600    T5K3,       T5IN              /RESET INPUT TTI POINTER
0165  7776    T5K5,     -2            /FOR SUBTRACTION
0166  0400    T5K6,       400       /TO RESET 5 BIT ASSEMBLY WORD
0167  6600    T5K7,     T5OBF         /K FOR 1ST OUTPUT BUFFER
0170  5221    T5K8,     T5COM         /TO ENTER COMMON ROUTINE
0171  0000    T5K9,     0             /LINE NUMBER -1
0172  6577    T5K9A,    T5OBF-1       /FOR CLEARING
0173  5237    T5K9B,    T5CM1A        /TO AVOID OUTPUTTING
0174  5361    T5K9C,    JMP T5CM10 /TO SET OUTPUT BUFFER FROM DOUBLE BUFFER
0175  5221    T5K9D,    T5COM         /FOR NORMAL RETURN
0176  7000    T5K9E,    NOP           /TO DO INPUT ONLY
                *TT5BGN
                /MULTIPLE LEVEL INTERRUPT ROUTINE
                /ALLOWS MULTIPLE LEVEL INTERRUPT TO THIS ROUTINE
                /AND UNLIMITED

5200  2366    T5DIS,      ISZ T5LC                  /LEVEL COUNTER
5201  5216        JMP T5DIS3                /2ND LEVEL INTERRUPT
5202  3367        DCA T5SA                  /SAVE ACCUMULATOR
5203  7010        RAR                 /GET LINK
5204  3370        DCA T5SVLK                /SAVE LINK
5205  1000        TAD Z 0             /INTERRUPT ADDRESS
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5206  3371        DCA T5SV0                 /SAVE ADDRESS
5207  6414            TTRL                      /READ LINE NUMBER
5210  3372            DCA T5SVLN                /SAVE LINE NUMBER
5211  6424            TT5ON                     /TO CLEAR CLOCK FLAG ONLY
5212  6001  T5DIS2,   ION                       /RE-ENABLE PROGRAM INTERRUPT
5213  1171            TAD T5K9                  /STARTING LINE-1
5214  6413            TTSL+1                    /SET LINE REGISTER, CLR AC
5215  5564        JMP I Z T5K3      /SET LINE REGISTER, CLR AC

              /2ND LEVEL INTERRUPT
5216  6424  T5DIS3,   TT5ON                     /CLEAR CLOCK FLAG
5217  6001            ION                       /RE-ENABLE PROGRAM INTERRUPT
5220  5400            JMP I Z 0                 /RETURN TO THE MAIN PROGRAM

              /RETURN FROM INPUT TTI LOOP
5221  1373  T5COM,    TAD T5MNC                 /-NO. OF LINES/8
5222  3155            DCA Z T5CNT2              /MINOR LOOP COUNTER
5223  1375            TAD T5LN                  /LINE NUMBER
5224  6413        TTSL+1            /SET LINE NUMBER
5225  1553  T5COM0,   TAD I Z T5OUTK            /OUTPUT WORD
5226  7450            SNA                       /CHARACTER AVAILABLE
5227  5351            JMP T5COM8                /NOTHING TO TRANSMIT
5230  6405            TT0+1                     /INCREMENT AND TRANSMIT
5231  3553            DCA I Z T5OUTK            /RESTORE CHARACTER
5232  2153  T5COM1,   ISZ Z T5OUTK             /UPDATE OUTPUT POINTER
5233  2155            ISZ Z T5CNT2              /ARE ONE-EIGHTH OF LINES DONE
5234  5225            JMP T5COM0                /CHECK NEXT OUTPUT LINE
5235  6414            TTRL                      /READ LINE NUMBER
5236  3375            DCA T5LN                  /SAVE LINE NUMBER
5237  1374  T5CM1A,   TAD T5MNC2                /NO OF LINES/4
5240  3155            DCA T5CNT2                /MINOR LOOP COUNTER
5241  2010  T5COM2,     ISZ T5AX1                   /ADVANCE FOR NEXT INPUT LINE
5242  1410        TAD I Z T5AX1     /CHARACTER ASSEMBLY WORD
5243  7112        CLL RTR           /PUT BIT 10 IN LINK
5244  7430            SZL                       /CHARACTER NOT COMPLETED
5245  5326            JMP T5COM6                /STORE CHARACTER
5246  7200            CLA                       /CLEAR AC FOR TAD
5247  7000  T5COM3,   NOP                       /OR JMP T5CM10
5250  2010            ISZ Z T5AX1               /UPDATE FOR NEXT INPUT LINE
5251  2376        ISZ T5LN2                 /UPDATE LINE NUMBER
5252  2155            ISZ T5CNT2                /ARE ONE-FOURTH OF LINES CHECKED?
5253  5241            JMP T5COM2                /CHECK NEXT LINE
5254  2154  T5COM4,   ISZ T5CNT1                /HAVE ALL INPUT LINES BEEN CHECKED
5255  5310            JMP T5COM5                /RESET AND DISMISS
5256  1164        TAD Z T5K3                /T5IN
5257  3010            DCA Z T5AX1               /RESET TTI POINTER
5260  1171        TAD Z T5K9                /START LINE-1
5261  7001        IAC               /SET TO FIRST LINE
5262  3376            DCA T5LN2                 /RESET LINE NUMBER
5263  1377            TAD T5K2A                 /-4
5264  3154            DCA T5CNT1                /INPUT CHECK COUNTER
5265  2161            ISZ Z T5CNT5              /HAVE ALL OUTPUT LINES BEEN CHECKED
5266  5310            JMP T5COM5                /RESET AND DISMISS
5267  1165            TAD Z T5K5                /-2
5270  3161            DCA Z T5CNT5              /RESET COUNTER
5271  1171            TAD Z T5K9                /START LINE-1
5272  3375            DCA T5LN                  /RESET LINE NUMBER
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5273  2162            ISZ Z T5CNT6          /ENDING 7TH BIT?
5274  5353            JMP T5COM9            /NO RESET NORMALLY
5275  1163            TAD T5K2              /-10
5276  3162            DCA Z T5CNT6          /RESET COUNTER
5277  2161            ISZ Z T5CNT5          /ADD 1 TO COUNTER
5300  1172            TAD Z T5K9A           /T5OBF-1
5301  3013            DCA Z T5AX4           /OUTPUT POINTER
5302  1160            TAD Z T5K36           /T5OBF2
5303  3153            DCA T5OUTK            /2ND BUFFER POINTER
5304  1173            TAD Z T5K9B           /SPECIAL ADDRESS, T5CM1A
5305  3170            DCA Z T5K8            /RESET ADDRESS
5306  1174            TAD Z T5K9C           /JMP T5CM10
5307  3247            DCA T5COM3            /SET TO DO OUTPUT
5310  6002  T5COM5,    IOF                   /TURN OFF INTERRUPT
5311  7240            STA                   /-1
5312  1366            TAD T5LC              /LEVEL COUNTER
5313  3366            DCA T5LC              /RESTORE LEVEL COUNTER
5314  1366            TAD T5LC              /LEVEL COUNTER
5315  7700            SMA CLA                   /RESTORE AC, ETC.
5316  5212            JMP T5DIS2          /CHECK INPUT AGAIN, ETC.
5317  1372            TAD T5SVLN            /LINE NUMBER
5320  6413            TTSL+1                  /SET LINE REGISTER, CLR AC
5321  1370            TAD T5SVLK          /PICK UP LINK
5322  7104            CLL RAL               /RESTORE LINK
5323  1367            TAD T5SA              /RESTORE AC
5324  6001            ION                   /RE-ENABLE PROGRAM INTERRUPT
5325  5771            JMP I T5SV0           /RETURN TO THE MAIN PROGRAM
5326  7112  T5COM6,     CLL RTR          /REMOVE START CODE
5327  7012         RTR
5330  3411            DCA I Z T5AX2         /STORE CHARACTER
5331  1376            TAD T5LN2             /LINE NUMBER
5332  3411            DCA I Z T5AX2         /STORE LINE NUMBER
5333  1010            TAD Z T5AX1           /TTI POINTER
5334  1165            TAD Z T5K5            /-2
5335  3010            DCA Z T5AX1           /RESET POINTER
5336  3410            DCA I Z T5AX1         /ZERO STATUS AND COUNTER WORD
5337  1166            TAD Z T5K6            /WORD TO RESTORE ASSEMBLY WORD
5340  3410            DCA I Z T5AX1         /RESET CHARACTER ASSEMBLY WORD
5341  2145            ISZ Z T5INFL          /SET INPUT READY FLAG
5342  2156            ISZ Z T5CNT3          /HAS END OF BUFFER BEEN REACHED?
5343  5247            JMP T5COM3            /CONTINUE
5344  1146  T5COM7,    TAD Z T5BFK           /T5IBF-1
5345  3011            DCA Z T5AX2           /RESET INPUT BUFFER ADDRESS
5346  1147            TAD T5NL              /--UMBER OF LINES
5347  3156            DCA Z T5CNT3          /RESET LENGTH COUNTER
5350  5247            JMP T5COM3            /CONTINUE
5351  6401  T5COM8,    TTINCR                /INCREMENT LINE NUMBER
5352  5232            JMP T5COM1            /CONTINUE
5353  1167  T5COM9,    TAD Z T5K7            /T5OBF
5354  3153            DCA Z T5OUTK          /RESET OUTPUT POINTER
5355  1175            TAD Z T5K9D           /NORMAL ADDRESS, T5COM
5356  3170            DCA Z T5K8            /RESET ADDRESS
5357  1176            TAD Z T5K9E           /NOP
5360  5307            JMP T5COM5-1          /CONTINUE
5361  1553  T5CM10,     TAD I Z T5OUTK    /2ND BUFFER CHARACTER
5362  3413            DCA I Z T5AX4           /STORE IN 1ST BUFFER
5363  3553            DCA I T5OUTK            /CLEAR 2ND BUFFER
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5364  2153            ISZ T5OUTK              /UPDATE POINTER
5365  5250            JMP T5COM3+1            /CONTINUE

                /CONSTANTS
5366  7777  T5LC,     -1                      /INTERRUPT LEVEL COUNTER
5367  0000  T5SA,     0                       /SAVE ACCUMULATOR
5370  0000  T5SVLK,   0                       /SAVE LINK
5371  0000  T5SV0,    0                       /SAVE PROGRAM COUNTER
5372  0000  T5SVLN,   0                       /SAVE LINE NUMBER
5373  0000  T5MNC,    0                       /-NO OF LINES/8
5374  0000  T5MNC2,   0                       /-NO OF LINES/4
5375  0000  T5LN,     0                       /LINE NUMBER FOR OUTPUT
5376  0000  T5LN2,    0                       /LINE NUMBER FOR INPUT
5377  7774  T5K2A,    -4                      /TO RESET MAJOR LOOP COUNTER
                /PSEUDO-OPERATIONS
                *TT5RGN+200
                /SKIP IF OUTPUT IS FREE AND TRANSMIT CHARACTER AT TTCHAR, OTHERWISE
                /DON'T SKIP LINE NUMBER MUST BE IN AC. 24US MIN., 42US MAX.
                T5SOF=JMS I Z T5SOUT
5400  0000  T5OUTS,   0
5401  0157            AND Z T5K10             /177
5402  1217            TAD T5SL                /-STARTING LINE NUMBER
5403  1160            TAD Z T5K36             /OUTPUT BUFFER ADDRESS
5404  3220            DCA T5WA                /WORK AREA
5405  1620            TAD I T5WA              /OUTPUT CHARACTER
5406  7640            SZA CLA                 /SKIP IF FREE
5407  5600            JMP I T5OUTS            /EXIT
5410  1177            TAD Z TTCHAR            /PICK UP CHARACTER
5411  0221            AND T5K11               /5 BITS ONLY
5412  1222            TAD T5K12               /140 FOR STOP CODE
5413  7104            CLL RAL                 /CREATE START CODE
5414  3620            DCA I T5WA              /STORE CHARACTER IN TABLE
5415  2200            ISZ T5OUTS              /INDEX EXIT
5416  5600            JMP I T5OUTS            /EXIT
5417  0000  T5SL,     0                       /-STARTING LINE NUMBER
5420  0000  T5WA,     0                       /WORK AREA
5421  0037  T5K11,    37                      /FOR 5 BIT CODE
5422  0040  T5K12,    40                      /FOR STOP CODE

                /SKIP IF CHARACTER AVAILABLE AND RETURN WITH LINE NUMBER IN AC
                /CHAR AT TTCHAR.  OTHERWISE DO NOT SKIP
                /15US MIN., 48US MAX., 37.5US NORMAL IF READY
                T5SIR=JMS I Z T5SIN
5423  0000  T5INS,    0
5424  6002      IOF
5425  7240      CLA CMA           /SET AC FOR TAD-1
5426  1145      TAD Z T5INFL      /INPUT FLAG COUNTER-1
5427  7510      SPA               /SOMETHING AVAILABLE
5430  5244      JMP T5INON                /EXIT
5431  3145            DCA Z T5INFL            /RESTORE FLAG COUNTER
5432  2246            ISZ T5CNT4              /END OF BUFFER?  START AT -N-1
5433  5240            JMP .+5                 /GET CHARACTER
5434  1147            TAD Z T5NL              /-NUMBER OF LINES
5435  3246            DCA T5CNT4              /RESET COUNTER
5436  1146            TAD Z T5BFK             /BUFFER ADDRESS-1
5437  3012            DCA Z T5AX3             /RESET ADDRESS
5440  1412            TAD I Z T5AX3           /PICK UP CHARACTER
5441  3177            DCA Z TTCHAR            /STORE CHARACTER
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5442  1412              TAD I Z T5AX3          /PICK UP LINE NO.
5443  2223              ISZ T5INS              /INDEX EXIT
5444  6001  T5INON,       ION
5445  5623              JMP I T5INS            /EXIT
5446  0000  T5CNT4,     0                     /-NUMBER OF LINES
            /INITIALIZATION ROUTINE
            /ENTER WITH NUMBER OF LINES IN AC
            /FORMAT    T5INIT
            /          1ST LINE NO.

            T5INIT=JMS I Z T5GO
5447  0000  T5GOS,      0
5450  0355              AND T5K14              /377
5451  3147              DCA Z T5NL             /NO. OF LINES
5452  1147              TAD Z T5NL             /NO. OF LINES
5453  0356              AND T5K15              /7
5454  7640              SZA CLA                /MULTIPLE OF 8
5455  1357              TAD T5K16              /10
5456  1147              TAD Z T5NL             /NO. OF LINES
5457  0360              AND T5K17              /370
5460  7041              CIA                    /TWO'S COMP. NUMBER OF LINES
5461  3147              DCA Z T5NL             /-N, CONSTANT
5462  1147  T5G01,      TAD Z T5NL             /-N
5463  3156        DCA Z T5CNT3    /COUNTER
5464  1361              TAD T5K20              /T5IN-1
5465  3010              DCA Z T5AX1            /TO STORE TTI TABLE
5466  1362              TAD T5K21              /T50BF-1
5467  3011              DCA Z T5AX2            /TO CLEAR OUTPUT AREA
5470  1373              TAD T5K37              /T80BF2-1
5471  3012              DCA T5AX3              /TO CLEAR DOUBLE BUFFER
5472  1147              TAD Z T5NL             /-N
5473  3246              DCA T5CNT4             /FOR COUNTING
5474  1363  T5G02,      TAD T5K22              /TTI+INCR
5475  3410              DCA I Z T5AX1          /STORE TTI
5476  3410              DCA I Z T5AX1          /CLEAR STATUS WORD
5477  1166        TAD Z T5K6              /ASSEMBLY RESET WORD
5500  3410              DCA I Z T5AX1          /RESET ASSEMBLY WORD
5501  3411              DCA I Z T5AX2          /ZERO OUTPUT WORD
5502  3412              DCA I Z T5AX3          /CLEAR DOUBLE BUFFER
5503  2246        ISZ T5CNT4              /COUNTER
5504  5274              JMP T5G02              /DO NEXT LINE
5505  1364              TAD T5K24              /JMP I Z T5K8
5506  3410              DCA I Z T5AX1          /STORE FINAL JUMP
5507  1147              TAD Z T5NL             /-N
5510  7012              RTR                    /-N/4
5511  7010              RAR                    /-N/8
5512  0365              AND T5K25              /17
5513  1366              TAD T5K26              /7760, MAKE NUMBER NEGATIVE
5514  3767              DCA I T5K27            /T5MNC
5515  1767              TAD I T5K27            /T5MNC
5516  1767              TAD I T5K27            /T5MNC. -N/4
5517  3774              DCA I T5K38            /T5MNC2
5520  7240              STA                    /-1
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5521  3246              DCA T5CNT4              /SET CNTR TO SKIP 1ST TIME
5522  1146              TAD Z T5BFK             /T5IBF-1
5523  3011        DCA Z T5AX2      /SET INPUT BUFFER POINTER
5524  1370              TAD T5K28               /-4
5525  3154              DCA Z T5CNT1            /MAJOR LOOP COUNTER
5526  1165              TAD Z T5K5              /-2
5527  3161              DCA Z T5CNT5            /OUTPUT COUNTER
5530  1164              TAD Z T5K3              /T5IN+1
5531  3010              DCA Z T5AX1             /SET TTI POINTER
5532  1167              TAD T5K7                /T5OBF
5533  3153              DCA Z T5OUTK            /SET OUTPUT BUFFER POINTER
5534  7240              STA                     /-1
5535  1647              TAD I T5GOS             /STARTING LINE NUMBER
5536  3171              DCA Z T5K9              /STARTING LINE NO-1
5537  1171              TAD Z T5K9              /STARTING LINE -1
5540  7040              CMA                     /MAKE NEGATIVE
5541  3217              DCA T5SL                /-STARTING LINE NUMBER
5542  3145              DCA Z T5INFL            /CLEAR INPUT FLAG COUNTER
5543  7240              STA                     /-1
5544  3771              DCA I T5K35             /T5LC, RESET INTERRUPT LEVEL COUNTER
5545  2247              ISZ T5GOS               /INDEX EXIT
5546  1372              TAD T5K35A              /-7
5547  3162              DCA Z T5CNT6            /SET SPECIAL 5-BIT COUNTER
5550  1175              TAD Z T5K9D             /T5COM
5551  3170              DCA Z T5K8              /TTI RETURN
5552  1176              TAD Z T5K9E             /NOP
5553  3775              DCA I T5K40             /T5COM3
5554  5647              JMP I T5GOS             /EXIT

          /CONSTANTS
5555  0377  T5K14,     377                     /FOR ANDING
5556  0007  T5K15,     7                       /FOR EVEN MULTIPLE OF 8
5557  0010  T5K16,     10                      /FOR EVEN MULTIPLE OF 8
5560  0370  T5K17,     370                     /FOR EVEN MULTIPLE OF 8
5561  5577  T5K20,     T5IN-1                  /FOR STORING TTI'S
5562  6577  T5K21,     T5OBF-1                 /FOR OUTPUT AREA
5563  6403  T5K22,       TTI+1           /TTI
5564  5570  T5K24,     JMP I Z T5K8            /FOR FINAL JUMP
5565  0017  T5K25,     17                      /FOR -N/8
5566  7760  T5K26,     7760                    /FOR MAKING NEGATIVE
5567  5373  T5K27,     T5MNC                   /FOR -N/8
5570  7774  T5K28,     -4                      /FOR MAJOR LOOP COUNTER
5571  5366  T5K35,     T5LC                    /FOR INTERRUPT LEVEL COUNTER
5572  7771  T5K35A,    -7                      /FOR 5-BIT COUNTER
5573  6777  T5K37,     T5OBF2-1                /FOR DOUBLE BUFFER
5574  5374  T5K38,     T5MNC2                  /FOR -N/4
5575  5247  T5K40,     T5COM3                  /FOR SWITCH
```

11. DIAGRAMS (Not Applicable)

12. REFERENCES

12.1 Other Library Programs

Digital-8-35-S-A
680 5-Bit Character Assembly Subroutines