PET ASCII OUTPUT PROGRAM FOR THE TIMEX/SINCLAIR ZX81

Introduction by Syncware News Technical Director, Fred Nachbaur

Here is another article by Carol F. Milazzo, describing a way of transmitting your ZX81 programs and data to other computers, such as the Commodore C64. As in her previous article (Audio Frequency Counter, SWN 2:5), Carol demonstrates some interesting and useful machine-code techniques which are readily applicable to other applications. One of the most fascinating aspects of the program (for me) is that it uses the ZX ROM's own "de-tokenizing" routines to send Sinclair BASIC in ASCII format. This is done by first printing (or listing) to the display file, then translating the contents of the display file to ASCII and shipping it out via a simple interface.

Ms. Milazzo's interface is designed specifically with the Commodore in mind. We are adding an alternate interface which provides an RS232-compatible output. You could then use your ZX81/TS1000 to send ASCII text to an RS232 terminal, printer, or other device. We'll leave the exact implementation up to you. Although parameters like baud rate and stop bits are elegantly catered to, others (like parity check bits, presence/absence of inverse characters or lower case) will have to be added if your outside device requires them.

Some of you may recall that we had intended to publish Bob Berch's article on driving RS232 printers with your ZX81. However, since Bob's implementation has been readily available from him for some time (and at a most reasonable price), and since it was considerably longer than we have had space for in this medium, we had to postpone it, and postpone it again. Ms. Milazzo's alternative is considerably shorter, and more easily extensible to other applications.

TS2068 CHALLENGES: Can any of you 2068'ers work out a similar way of shipping ASCII text via your EAR port? This one should be easy, since your character set is already coded in ASCII. How about a routine for transmitting ZX8I programs/data to the 2068, and vice versa, through the MIC and EAR ports? In this case, you might want to take a slightly different approach, and translate the tokens as well as the alphanumeric and symbol characters. Also, you'll have to figure out a way to emulate a tape signal (Hint: "borrow" the required code snippets from the 2068 EXROM, and from David Wood's book "Practical Guide to M/L on the TS1000").

Whatever your preference machine-wise, we hope you can find uses for the techniques presented here.

Milazzo, Carol F., "PET ASCII Output Program for the Timex/Sinclair ZX81", *Syncware News*, Vol 3:3, January-February 1986. A Z80 machine language program to port ZX81 programs and data to other computers.

INTRODUCTION

This article describes a project which may be useful for anyone desiring to use software for the ZX81, TS1000 or TS1500 on a different computer. The program version presented here is designed to convert Sinclair BASIC programs into ASCII text which can be sent from the Sinclair computer to the serial port of a Commodore C64 computer. The program can be used with other computers if the non-standard graphic characters are eliminated or appropriately changed. In addition to the program presented here, the user will require a terminal program that permits the receiving computer to download and save text, e.g. "Plus/Term" in Feb. 1985 Compute!, and a very simple hardware circuit to interface the computers.

The program described here consists of a portion in BASIC which is used to set the parameters, and to relocate the 327-byte Zilog Z80 machine language (ML) program which is in the first REM statement. Typically, 327 bytes can be reserved above RAMTOP by lowering it to 32441 (in 16K) using the following sequence: POKE 16388,185; POKE

16389,126; NEW; then LOAD "PET ASCII".

THE BASIC PROGRAM

Upon running the BASIC program, the prompt "RELOCATE?" will appear. Enter "N" or ENTER alone if you desire to run the ML program at its original location in the REM statement. The response "Y" will cause the computer to request "NEW LOCATION=" which should be answered with 32441 in this example. Lines 110-140 copy the ML program to the new location and lines 150-220 make the required adjustments to the addresses in the ML code. The computer will then print "OUTSCREEN = RAND USR 32568, OUTPROG = PRINT USR 32568". This information should be noted, as these are the commands required to send a display screen or a BASIC program listing as ASCII text.

The computer then requests, "BAUD RATE?", which can be selected up to 2400 baud. Then it prompts "STOP BITS?" to select the number of stop bits between characters. By experience, one stop bit is usually sufficient for data speeds up to 1200 baud. At least 2 stop bits should be used for higher speeds.

In lines 290-400, the program calculates the required constants and POKEs them into the appropriate locations. The variable F in line 310 is set to the computer's clock frequency, nominally 3.25 MHz. Variable G in line 320 represents a fixed number of clock cycles in the bit length delay loop. (The "+10" adjusts the duration of the M/L commands at 40D3h and 40D4h, which only exist to allow a very fine adjustment in bit duration.) Then, "PRESS ENTER TO TRANSFER PROGRAM," and the ML routine is activated. (You can use this as a "test run" to make sure your system is working before transferring other programs.)

After the original program is NEWed, any desired BASIC program can be LOADed and transferred to a receiving computer by entering PRINT USR 32685, since the ML program is protected from the NEW command.

```
0 REM...(327 BYTES FOR ML)...
10 REM PET ASCII OUTPUT PROGRAM BY CAROL F. MILAZZO
20 PRINT "RELOCATE?"
30 INPUT A$
40 CLS
50 LET ORG=16514
60 LET DIS=0
70 IF A$<"Y" THEN GOTO230
80 PRINT "NEW LOCATION=";
90 INPUT LOC
100 PPINT LOC
110 LET DIS=LOC-ORG
120 FOR I=ORG TO ORG+326
130 POKE I+DIS,PEEK I
140 NEXT I
150 LET A$="166011661416619166261668416726167381674816753167881683216839"
160 FOR 1=1 TO 56 STEP 5
170 LET A=VAL A$(I TO I+4)
180 LET AD=PEEK A+256*PEEK (A+1)+DIS
190 LET H=INT (AD/256)
200 POKE A+DIS+1,H
210 POKE A+DIS,AD-256*H
220 NEXT I
230 LET BH=16587+DIS
```

```
240 LET BL=16588+DIS
250 LET SB=16624+DIS
260 LET OS=16641+DIS
270 LET OP=16758+DIS
280 PRINT "OUTSCREEN = RAND USR ";OS,"OUTPROG = PRINT USR ";OP
290 PRINT "BAUD RATE? ";
300 INPUT R
310 LET F=3.25E6
320 LET G-93+10
330 LET M=INT (F/R+.5)
340 LET C=INT ((M-G+3310)/3339)
350 LET B=(M-G-3339*C+3323)/13
360 POKE BH,C
370 POKE BL,INT B
380 PRINT R,,"STOP BITS? "
390 INPUT S
400 POKE SB,S
410 PRINT S,,"PRESS ENTER TO TRANSFER PROGRAM"
420 INPUT A$
430 PRINT USR OP
440 PRINT "BYTES"
450 PRINT
460 GOTO290
470 SAVE "PET ASCII"
480 RUN
```

THE MACHINE-LANGUAGE PROGRAM

The addresses given here refer to the original location of the ML program in the REM statement. The entry point for program transmission is at label OUTPROG (4176h). The computer is placed in FAST mode, and a 10 second silence follows. If required, the receiving computer's text buffer should be opened during this time. The text byte counter (407Bh) is zeroed, and the beginning address of the program is stored at 403Ch. A CONTROL Q is transmitted to signal beginning of transmission. At label NEWSCREEN (4196h) the screen is cleared. A check for BREAK is made, and a check is done to see if the end of the program has been reached. If either condition is true, then the program jumps to EXIT (41C4h). A CONTROL C is sent, signalling end-of-transmission, and the routine returns to BASIC with the byte-count in the BC register pair.

Otherwise, the successive program lines are printed on the screen, and from there are transmitted by a call to the OUTSCREEN subroutine. This routine will stop and display any line exceeding the 704 raster screen size. Such lines should be deleted to enable OUTPROG to transfer the program. The CONTROL characters are sent in case the receiving terminal program requires them for text loading. They may be changed as required by POKEing the needed values at 4192h and 41C5h.

The OUTSCREEN subroutine transmits text printed on the screen up to the display file character counter (DF-CC), which is used as an end marker. At 4101h, the blank spaces after the last screen line are eliminated by adjusting DF-CC to point right after the last printed character. The screen contents are then scanned and converted at OUTCHAR to PET ASCII characters and graphic symbols, with any appropriate RVS ON and RVS OFF characters. When the last screen character is sent, a jump is made to OUTCR which sends a carriage return and exits the subroutine.

The OUTBYTE subroutine (40D8h) sends out each byte (loaded into the E register) through the computer's TV/TAPE port. Each bit is rotated through the carry bit, and the appropriate SPACE or MARK subroutine is called. The text byte counter is incremented before exiting back to the calling routine.

```
PET ASCII OUTPUT MACHINE LANGUAGE PROGRAM FOR ZX81 BY CAROL F. MILAZZO

TABLE   4082    20 BE BC A2 BB Al BF AC A6 A8 A2 22 5C 24 3A 3F
        4092    28 29 3E 3C 3D 2B 2D 2A 2F 3B 2C 2E 36 31 32 33
        40A2    34 35 36 37 38 39 41 42 43 44 45 46 47 48 49 4A
        4082    4B 4C 40 4E 4F 50 51 52 53 54 55 56 57 58 59 5A
MARK    40C2    DBFE            IN A,(FE)
        40C4    1804            JR DELAY
SPACE   40C6    D3FF            OUT (FF),A
        40C8    1800            JR DELAY
DELAY   40CA    01015F          LD BC,5F01      (2400 BAUD RATE CONSTANT)
LOOP    40CD    lOFE            DJNZ LOOP
        40CF    0D              DEC C
        40D0    20FB            JRNZ LOOP
        40D2    AF              XOR A
        40D3    C0              RET NZ
        40D4    C0              RET NZ
        40D5    C9              RET
OUTCR   40D6    lE0D            LD E,0D         (SEND CR)
OUTBYTE*40D8    CDC640          CALL SPACE      (START BIT)
        40DB    00              NOP
        40DC    00              NOP
        40DD    37              SCF
NEXTBIT 40DE    CBlB            RR E            (FETCH EACH DATA BIT)
        40E0    280D            JRZ STOP
        40E2    3006            JRNC SP
        40E4    D0              RET NC
*       40E5    CDC240          CALL MARK
        40E8    18F4            JR NEXTBIT
SP*     40EA    CDC640          CALL SPACE
        40ED    18EF            JR NEXTBIT
STOP    40EF    1E02            LD E,02         (# OF STOP BITS)
STOPBIT*40F1    CDC240          CALL MARK
        40F4    1D              DEC E
        40F5    20FA            JRNZ STOPBIT
        40F7    ED4B7B40        LD BC,(407B)
        40FB    03              INC BC          (INCREMENT BYTE
COUNTER)
        40FC    ED437B40        LD (407B),BC
        4100    C9              RET
OUTSCREEN4101   2A0E40          LD HL,(DF-CC)
        4104    AF              XOR A
COLLAPSE4105    2B              DEC HL          (COLLAPSE LAST SCREEN
LINE)
        4106    BE              CP (HL)
        4107    28FC            JRZ COLLAPSE
        4109    CB76            BIT 6,(HL)
        410B    20F8            JRNZ COLLAPSE
        410D    23              INC HL
        410E    220E40          LD (DF-CC),HL
OUTSCR2 4111    1600            LD D,00         (RVS FLAG OFF)
        4113    2A0C40          LD HL,(D-FILE)
NEXTCHAR4116    23              INC HL
        4117    E5              PUSH HL
        4118    ED4B0E40        LD BC,(DF-CC)   (CHECK FOR END OF
SCREEN)
        411C    A7              AND A
        411D    ED42            SBC HL,BC
        411F    7C              LD A,H
        4120    B5              OR L
        4121    E1              POP HL
        4122    28BB            JRZ OUTCR       (RETURN IF END)
        4124    7E              LD A,(HL)       (FETCH A CHARACTER)
        4125    FE76            CP 76
        4127    2007            JRNZ OUTCHAR
        4129    18EB            JR NEXTCHAR     (1800 TO SEND CR AFTER EACH LINE)
ENDLINE*412B    CDD640          CALL OUTCR
        412E    18E6            JR NEXTCHAR
OUTCHAR 4130    07              RLCA
        4131    FE16            CP 16
        4133    3016            JRNC NORM
        4135    FE06            CP 06
        4137    3812            JRC NORM
        4139    FE08            CP 08
        413B    380C            JRC INV
        413D    FE0C            CP 0C
        413F    380A            JRC NORM
        4141    FE12            CP 12
        4143    3804            JRC INV
        4145    FE14            CP 14
        4147    3802            JRC NORM
INV     4149    EE01            XOR 01
NORM    414B    CB3F            SRL A
        414D    F5              PUSH AF
        414E    300C            JRNC RVS-OFF
RVS-ON  4150    15              DEC D
        4151    2805            JRZ SET-D
        4153    1E12            LD E,12         (SEND RVS-ON)
*       4155    CDD840          CALL OUTBYTE
SET-D   4158    1601            LD D,01
        415A    180A            JR CONT
RVS-OFF 415C    15              DEC D
        415D    2005            JRNZ RESET-D
        415F    1E92            LD E, 92        (SEND RVS-OFF)
*       4161    CDD840          CALL OUTBYTE
RESET-D 4164    1600            LD D,00
```

```
CONT    4166    Fl              POP AF
        4167    E5              PUSH HL
        4168    0600            LD B,00         (TRANSLATE ZX81 TO PET
ASCII)
        416A    4F              LD C,A
*       416B    218240          LD HL,TABLE
        416E    09              ADD HL,BC
        416F    5E              LD E,(HL)
*       4170    CDD840          CALL OUTBYTE
        4173    El              POP HL
        4174    18A0            JR NEXTCHAR
OUTPROG 4176    CDE702          CALL FAST
        4179    210024          LD HL,2400
DELAYl  417C    CD460F          CALL BREAK-1    (CHECK FOR BREAK KEY)
        417F    D0              RET NC          (EXIT IF BREAK PRESSED)
DELAY2  4180    l0FE            DJNZ DELAY2
        4182    48              LD C,B
        4183    2B              DEC HL
        4184    7C              LD A,H
        4185    B5              OR L
        4186    20F4            JRNZ DELAYl
        4188    227B40          LD (407B),HL    (ZERO BYTE COUNTER)
        418B    217D40          LD HL,PROGRAM   (START OF PROGRAM)
        418E    22EC40          LD (403C),HL
        4191    1E11            LD E,11         (SEND CONTROL Q)
*       4193    CDD840          CALL OUTBYTE
NEWSCREEN4196   CD2A0A          CALL CLS        (CLEAR SCREEN)
        4199    CD460F          CALL BREAK-l    (CHECK BREAK KEY)
        419C    3026            JRNC EXIT       (EXIT IF BREAK PRESSED)
        419E    2A3C40          LD HL,(403C)    (CHECK FOR END OF
PROGRAM)
        41A1    ED4B0C40        LD BC,(D-FILE)
        41A5    A7              AND A
        41A6    ED42            SBC HL,BC
        41A8    7C              LD A,H
        41A9    B5              OR L
        41AA    2818            JRZ EXIT
        41AC    2A3C40          LD HL,(403C)
        41AF    CD4507          CALL PRLINE     (PRINT NEXT BASIC LINE)
        41B2    2A3C40          LD HL,(403C)
        41B5    23              INC HL
        41B6    23              INC HL
        41B7    4E              LD C,(HL)
        41B8    23              INC HL
        41B9    46              LD B,(HL)
        41BA    23              INC HL
        41BB    09              ADD HL,BC
        41BC    223C40          LD (403C),HL    (STORE ADDRESS OF NEXT LINE)
*       41BF    CD0141          CALL OUTSCREEN  (SEND SCREEN)
        41C2    18D2            JR NEWSCREEN
```

```
EXIT    41C4    1E03            LD E,03         (SEND CONTROL C)
*       41C6    C3D840          JP OUTBYTE

* THESE INSTRUCTIONS REQUIRE OFFSET CALCULATIONS WHEN RELOCATED

CHANGE THE FOLLOWING LINES TO GET STANDARD ASCII OUTPUT FOR OTHER COMPUTERS
BY ELIMINATING THE REVERSE AND GRAPHIC CHARACTERS:

TABLE   4082    20 20 20 20 20 20 20 20 20 20 20 22 5C 24 3A 3F
OUTCHAR 4130    E63F            AND 3F
        4132    1833            JR CONT+1
```

TRANSFERRING OTHER DATA

After transferring a program, any arrays or other values in the variables area may also be transmitted by printing them, using BASIC statements, then using RAND USR OUTSCREEN. For example, a 100-element numeric array A(100) can be sent by entering the following lines, and executing GOTO 1:

```
1 FAST
2 FOR 1=1 TO 2000
3 NEXT I
4 LET OUTSCREEN=32568 (ML above 32441)
5 LET AD=9000
6 GOSUB 21
7 PRINT " DIM A(100):FOR I=1 TO 100:READ A:NEXT I"
8 GOSUB 18
9 FOR I=0 TO 95 STEP 5
10 PRINT " DATA ";
11 FOR J=1 TO 5
12 PRINT A(I+J);
13 IF J<5 THEN PRINT ".";
14 NEXT J
15 GOSUB 18
16 NEXT I
17 STOP
18 RAND USR OUTSCREEN
19 LET AD=AD+10
20 CLS
21 PRINT AD;
22 RETURN
```

Graphic displays can also be sent by using the OUTSCREEN subroutine. OUTSCREEN normally ignores the NEWLINE character at the end of each display line, but for sending graphic displays these should be used to send a carriage return (CR). This is done by POKEing 00 at 412Fh. Displays produced using the AT command may set DF-CC before the end of the screen text, causing OUTSCREEN to send only that part up to DF-CC. This can be corrected by inserting the command PRINT AT 21,31; before the RAND USR OUTSCREEN within the program. Non-ASCII text, e.g. machine-language files, can be transmitted by using the OUTCR subroutine. Each text byte must be POKEd into 40D7h, followed by executing RAND USR OUTCR. For example:

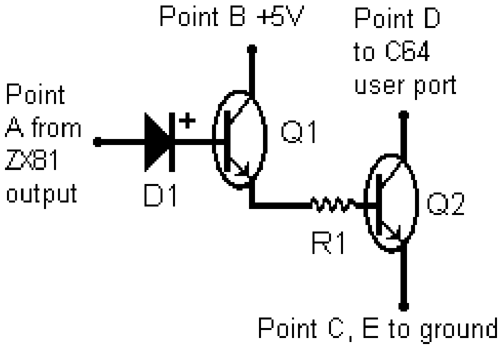
```
1 FAST
```

```
2 FOR 1=1 TO 2000
3 NEXT I
4 LET OUTCR-32525 (ML above 32441)
5 FOR 1=32441 TO 32767 (Send PET ASCII program)
6 POKE OUTCR+1,PEEK I
7 RAND USR OUTCR
8 NEXT I
```

THE INTERFACE

The hardware interface for the C64 is shown in Figure 1, and consists of the following components:

Figure 1. Schematic diagram of hardware interface to connect the output of the Timex/Sinclair ZX81 to a Commodore 64 computer.



PART	RADIO SHACK#	DESCRIPTION
D1	276-1122	1N914 diode
Q1, Q2	276-2009	NPN silicon transistor, 2N2222 etc.
R1	271-010	68 ohm 1/2W resistor
SO1	C1-12	24-contact polarizing connector (DIGI KEY)
	CR1164-1	2 polarizing keys for SOl (DIGI KEY)

Point "A" is connected to the TV/TAPE output of the computer logic chip. This is pin 16 of IC1 (ULA) on the ZX81/TS1000 (junction of D9 and R29), or pin 53 of U5 (SCLD) on the T51500 (junction of D19 and R20). Point "B" is connected to +5V, and point "C" is connected to ground. In the interface circuit, D1 is used to protect the computer logic chip in case of Q1 failure. Q1 is connected as an emitter follower, identical to the common video output modification for these machines. Q2 converts the signal from Q1 to provide the proper on-off switching required by the Commodore user port. The edgeboard connector is used to connect the interface to the Commodore 64 user port. Point D is connected to pins B and C, and point E is connected to pin A of the user port.

OPERATION

In typical operation, the receiving computer is connected and set to the desired data speed and 8 bit word length. The Sinclair ML program is set up above RAMTOP as described, or in CMOS RAM or other available memory. The desired BASIC program is loaded into the Sinclair/Timex in the usual manner. The command PRINT USR [OUTPROG address] is executed, and the text buffer of the receiving computer is opened. The actual ASCII data transmission is seen as varying horizontal bars on the Sinclair monitor screen. Transmission may be aborted at any time by holding the BREAK key.

After any text transmission is terminated, the number of bytes sent is displayed in the upper left corner of the screen. The text buffer in the receiving computer should be closed, and the transmitted text saved to disk or tape. This ASCII file must be converted into BASIC tokens. The PLUS/TERM program described above includes a utility called "TOKENIZER", which performs this task for disk-drive users. Another utility program called "RECRUNCHER" appeared in July 1985 "Compute!" and works with tape or disk drive. Sinclair BASIC programs will rarely run on other computers without some translation of commands. Translation can be done line-by-i me, or with the aid of a utility like "METABASIC" in April 1985 "Compute Gazette."

CONCLUSION

This project is a worthwhile investment, and has saved me the hundreds of thousands of keystrokes that the transfer of an extensive collection of programs would have required. I would appreciate any suggestions for improvements, or other feedback from users. (Send them directly to me, or care of this magazine.) I will supply this program on cassette to anyone who sends a nominal $5 for the tape and postage.

FIGURE 2

Here is an alternate interface circuit, which provides an RS232-compatible output signal. It uses an LM311 comparator, which is inexpensive, capable of about 100 mA output drive, and is commonly available. However, you could use other comparators or op amps instead.

Power can be provided with a bi-polar 9V supply, or from two 9V "transistor" batteries. Depending on the output drive requirement, a pair of alkaline batteries can run for up to about 28 hours. Note that the power on/off switch must be double-pole, to insure that both batteries are disconnected.

The connection shown is for a non-inverting configuration. If your system requires the signal to be inverted, exchange the two connections marked with "X".

Resistor R3 provides hysteresis (positive feedback) for rapid output transistions. Bypass capacitors Cl and C2 are for glitch-protection, and should be tantalum types rated at 10V or better. Exact capacitance values are non-critical, anywhere from .47 uF to 10 uF. is fine.