Extensions to Basic *John Richard Coffey*

Introduction

The Z80 microprocessor is the brain of your Sinclair computer. By itself, however, it is not very smart. It has no capacity to understand commands like PRINT and LET. When you use these commands, you are not directly telling the Z80 what to do. What the commands do is give instructions to the *interpreter.* The interpreter is itself a computer program and is located in memory locations 0 to 8191. It is written in a language the Z80 can understand called "machine language" or "machine code." This language consists of numbers between 0 and 255. A table of these numbers and their mnemonics can be found in the Basic manual. A mnemonic is a label assigned to each machine code that more or less describes what it does.

We can write our own machine code programs, but it is not an easy process. The main advantage to writing them is that they execute very fast. They also do not take up much memory and sometimes are more flexible than Basic. The three Basic commands that deal with machine code are PEEK, POKE, and USR. PEEK allows you to examine a memory location and POKE allows you to change it. The USR routine tells the Z80 to start executing machine code at a particular location. Before you can use the POKE command to put numbers into memory you must first reserve an area for them. The Basic manual gives a detailed discussion of how to do this.

Presented below in Figure 1 are four machine code routines which imitate features that are standard on more expensive computers and that will extend your 8K ROM by adding new commands.

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Figure 1. Summary of new routines.

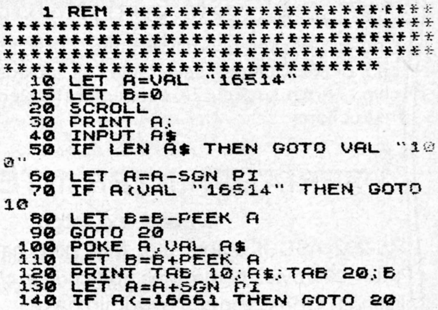
The Routines

COMMAND	DESCRIPTION
10 RAND USR IV	Convert every character on screen to its inverse.
10 PRINT USR FM	Print how many free bytes are in memory.
10 GOTO Z	Create an inverse program listing.
10 REM 10.3, SIN A, 500 REM ABE,IKE	These are two pseudo-DATA statements. They can be placed anywhere in your program. Each entry can be numeric or string and is followed by a comma.
10 RAND USR RS	Perform the RESTORE command. This must be used before any data is read. It can also be used to read data more than once.
10 LET A$="" 20 RAND USR RD 30 LET A=VAL A$	READ the next data entry. Omit line 30 if you are reading a string.

Use Listing 1 to enter the machine code listed in Figures 2 through 5. Verify your articles with both the addresses and the checksums printed by the program. If you make a mistake, simply press to enter to erase the last entry. 1K users will have to use CONT when screen overflow causes the program to stop. After you type the last number, the program should stop. You should then delete all the lines of the program except the first by typing in the line number and ENTER.

With the one line still in memory, type and RUN Listing 2. It will save itself to tape, so prepare your recorder in advance. After the SAVE, press ENTER. The screen will flicker for a moment and Listing 2 will be gone. The machine code, however, will have been relocated to the top of whatever memory size you have.

Listing 1. Machine Language Loader.



```
   1 REM ************************
********************************
********************************
********************************
****************************
  10 LET A=VAL "16514"
  15 LET B=0
  20 SCROLL
  30 PRINT A;
  40 INPUT A$
  50 IF LEN A$ THEN GOTO VAL "10
0"
  60 LET A=A-SGN PI
  70 IF A<VAL "16514" THEN GOTO
10
  80 LET B=B-PEEK A
  90 GOTO 20
 100 POKE A,VAL A$
 110 LET B=B+PEEK A
 120 PRINT TAB 10;A$;TAB 20;B
 130 LET A=A+SGN PI
 140 IF A<=16661 THEN GOTO 20
```

Listing 3 demonstrates the use of the various commands. It also declares the variables RS, RD, IV, FM, and Z. Note that Z is read from a REM statement. Start your recorder before running Listing 3, because it will also SAVE itself to tape. Afterwards you may want to delete all the lines except the last two, and

SAVE result. If you have not used NEW or CLEAR, then the variables will go to tape also.

The procedure for LOADING the new commands is simple: LOAD Listing 2. Press ENTER. LOAD Listing 3 or its shortened version described above. Caution: This short version will only work if you are using the same memory configuration you were using before the SAVE. It is a good idea to hold onto all of Listing 3 in case you need it.

Practical Uses

If you have a long print out and little memory, you will probably get an error "4" due to screen overflow. This can be prevented with a line such as the following:

50 IF USR FM < 100 THEN CLS

This will let you avoid having to type "CONT" to get your program going again. It might be a little annoying, however, if the screen clears without your having a chance to read it. So, perhaps the following two lines would be better:

50 IF USR FM < 100 THEN PAUSE 40000
60 IF USR FM < 100 THEN CLS

This stops the program until you have had a chance to read the screen. Pressing any key will get it going again and will also clear the screen. Which version you use depends upon your application.

You can use the instant inverse routine to create some interesting visual effects. Listing 4 is a good attention catcher and would be useful in a shop window or in an exhibit at a computer fair. The first two lines create a collapsed display file and should be used only if you are using an expansion memory. Listing 5 shows how to create a full display (2K version). Listing 6 is a 1K version of the same thing.

Listing 2.

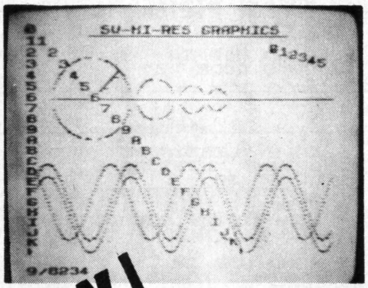
```
  10 SAVE "2"
  20 LET A=VAL "PEEK 16388+256*P
EEK 16389"
  30 INPUT B$
  40 POKE 16515,129
  50 LET A=A-120
  60 LET B=A+3
  70 LET C=VAL "16550"
  80 GOSUB VAL "130"
  90 LET B=A+29
 100 LET C=VAL "16566"
 110 GOSUB 130
 120 PRINT USR 16634
 130 LET E=VAL "INT (B/256)"
 140 LET D=B-E*256
 150 POKE C,D
 160 POKE C+SGN PI,E
 170 RETURN
```

On the television set that I use, inverse characters are much easier to read than normal ones. This is why I have included a "GOTO Z" feature. For me it is the only way I can read my programs. Not everyone will have this problem, but I am sure there are a few who do.

Listing 3.

```
   1 SAVE "3"
  10 LET RS=VAL "PEEK 16388+256*
PEEK 16389"
  20 LET RD=RS+42
  30 LET FM=RS+79
  40 LET IV=RS+94
  50 REM COMMANDS :(USR ) FM IV
RS RD , AND GOTO Z,9998,
  60 PRINT USR FM
  70 RAND USR RS
  75 FOR L=1 TO 3
  80 LET A$=""
  90 RAND USR RD
 100 IF L<3 THEN PRINT A$
 105 NEXT L
 110 LET Z=VAL A$
9998 LIST
9999 RAND USR IV
```

If you have to do any kind of record keeping, then the restore and read routines should be helpful. You can use



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the REM statements to store important telephone numbers, dates, appointments, birthdays, etc. They could also hold inventories, screen coordinates for plotting, machine code, or words like "CAT" and "DOG" for a computer version of "Hangman."

Listing 7 is an example of a computer telephone directory that runs in 1K. The other ideas mentioned above I will leave as exercises for interested programmers. Feel free to substitute other phone numbers in line 10. This same program can be used to store other kinds of data where one item is directly related to another. An English to Spanish translator would be an example.

Listing 8 will graph any function you give it. First, you must input the function in terms of X. For example, if you wanted to graph (f(X) = $4X^2+3X+2$) then you would input 4*X*X+3*X+2. Then you have to input the lower and upper limits on X. If you were plotting a sine curve, for example, you would probably want to use limits of zero and two pi. The nice thing about this program is that the vertical limits are calculated automatically. This makes function plotting quite a bit easier.

Stored on REM statements are some functions you can select instead of your own. Each function is followed by its

Figure 2. Restore and READ String Routines.

Assembly	Listing	Address	Machine	Code		Checksum
RESTORE	LD HL,16634	16514	33	250	64	347
FIND	LD A,CODE "REM"	16517	62	234		643
	LD BC,65536	16519	1	255	255	1154
	CPIR	16522	237	177		1568
	LD BC,5	16524	1	5	0	1574
	AND A	16527	167			1741
	SBC HL,BC	16528	237	66		2044
	LD A,118	16530	62	118		2224
	CP (HL)	16532	190			2414
	JR Z,BELOW	16533	40	5		2459
	ADD HL,BC	16535	9			2468
STASH	LD (16507),HL	16536	34	123	64	2689
	RET	16539	201			2890
BELOW	ADD HL,BC	16540	9			2899
	JR FIND	16541	24	230		3153
READ						
CHARACTER	LD HL,(16507)	16543	42	123	64	3382
	LD A,118	16546	62	118		3562
	CP (HL)	16548	190			3752
	CALL Z,FIND	16549	204	33	64	4053
	LD A,(HL)	16552	126			4179
	INC HL	16553	35			4214
	JR STASH	16554	24	236		4474
READ						
STRING	LD HL,(E-LINE)	16556	42	20	64	4600
	DEC HL	16559	43			4643
	PUSH HL	16560	229			4872
	DEC HL	16561	43			4915
	DEC HL	16562	43			4958
	EX (SP),HL	16563	227			5185
LOOP	PUSH HL	16564	229			5414
	CALL READ					
	CHARACTER	16565	205	159	64	5842
	POP HL	16568	225			6067
	LD B,CODE","	16569	6	26		6099
	CP B	16571	184			6283
COMA DONE	JR Z,DONE	16572	40	13		6336
	LD (HL),A	16574	119			6455
	INC HL	16575	35			6490
INC LEN$	EX (SP),HL	16576	227			6717
	INC (HL)	16577	52			6769
	JR NZ,NO CARRY	16578	32	3		6804
	INC HL	16580	35			6839
	INC (HL)	16581	52			6891
	DEC HL	16582	43			6934
NO CARRY	EX (SP),HL	16583	227			7161
DO MORE	AND A	16584	167			7328
	JR NC,LOOP	16585	48	233		7609
DONE	EX (SP),HL	16587	227			7836
	POP HL	16588	225			8061
	NOP	16589	0			8061
	JP ROM	16590	195	157	20	8433

Figure 3. FREE MEMORY Routine.

Assembly	Listing	Address	Machine	Code		Checksum
FREE MEM	LD HL, (STKEND)	16593	42	28	64	8567
	LD B,H	16596	68			8635
	LD C,L	16597	77			8712
	LD HL,0	16598	33	0	0	8745
	ADD HL,SP	16601	57			8802
	CP A	16602	191			8993
	SBC HL,BC	16603	237	66		9296
	LD B,H	16605	68			9364
	LD C,L	16606	77			9441
	RET	16607	201			9642

Listing 4.

```
   1 SAVE "LISTING 4"
   2 LPRINT "LISTING 4",,,,"USE 
FIRST TWO LINES ONLY WITH EXPANS
ION MEMORY",,,,"GRAPHICS KEYS IN
 LINE 30:5374TY5T55885E4W64261YT
58",,
   3 LLIST 10
   4 LPRINT " SLOW ",," GOTO 0"
   5 STOP
  10 POKE 16389,68
  20 CLS
  30 PRINT AT VAL "9",VAL "2";"[illegible]
[illegible]";AT VAL "10",VAL "2"
;"[illegible]";AT VAL "11",VAL 
"2";"[illegible]"
  40 FOR Z=NOT PI TO CODE "+"
  50 UNPLOT Z+Z,Z
  55 UNPLOT Z+Z+SGN PI,CODE "F"-
Z
  60 NEXT Z
  63 RAND USR IV
  70 GOTO CODE "Z"
```

Listing 5.

```
  1 SAVE "LISTING 5"
  2 LPRINT "LISTING 5",,,,
  3 LLIST 10
  4 LPRINT " GOTO 0"
  5 STOP
 10 POKE 16389,255
 20 CLS
 30 SLOW
 40 RAND USR IV
 50 FOR A=1 TO 30
 60 NEXT A
 70 GOTO 40
```

Listing 6.

```
  1 SAVE "LISTING 6"
  2 LPRINT "LISTING 6",,,,
  3 LLIST 10
  4 LPRINT " SLOW ",," GOTO 0"
  5 STOP
 10 FOR Z=NOT PI TO CODE "("
 20 PRINT TAB CODE "3"
 30 NEXT Z
 40 RAND USR IV
 50 GOTO CODE "A"
```

Listing 7.

```
   1 SAVE "LISTING 7"
   2 LPRINT "LISTING 7",,,,
   3 LLIST 10
   4 LPRINT " GOTO 0"
   5 STOP
  10 REM JOHN,752-5106,MIKE,752-
5379,CRUMP,895-4809,
  20 PRINT " INPUT NAME"
  30 INPUT A$
  40 RAND USR RS
  50 LET B$=""
  60 RAND USR RD
  70 IF B$="DATA OUT" THEN GOTO
VAL "20"
  80 LET C$=""
  90 RAND USR RD
 100 IF B$<>A$ THEN GOTO VAL "50
"
 110 PRINT C$
 120 GOTO VAL "20"
 130 REM DATA OUT,
```

Figure 4. INSTANT REVERSE Routine.

Assembly Listing		Address	Machine Code			Checksum
IV	LD HL,(D-FILE)	16608	42	12	64	9760
	LD B,H	16611	68			9828
	LD C,L	16612	77			9905
	LD D,59	16613	22	59		9986
	SLA D	16615	203	34		10223
LOOP	LD HL,(VARS)	16617	42	16	64	10345
	LD A,(BC)	16620	10			10355
	CP D	16621	186			10541
	JR Z,AGAIN	16622	40	3		10584
	ADD A,128	16624	198	128		10910
	LD (BC),A	16626	2			10912
AGAIN	INC BC	16627	3			10915
	CP A	16628	191			11106
	SBC HL,BC	16629	237	66		11409
	JR NZ,LOOP	16631	32	240		11681
	RET	16633	201			11882

Figure 5. RELOCATION Routine.

Assembly Listing		Address	Machine Code			Checksum
RELOCATE	LD HL,(RAMTOP)	16634	42	4	64	11992
	LD BC,-120	16637	1	136	255	12384
	ADD HL,BC	16640	9			12393
	PUSH HL	16641	229			12622
	PUSH HL	16642	229			12851
	EXX	16643	217			13068
	POP BC	16644	193			13261
	EXX	16645	217			13478
	LD HL,16514	16646	33	130	64	13705
	POP DE	16649	209			13914
	LD BC,120	16650	1	120	0	14035
	LDIR	16653	237	176		14448
	EXX	16655	217			14665
	DEC BC	16656	11			14676
	OUT 253,A	16657	211	253		15140
	JP NEW	16659	195	203	3	15541

Listing 8.

```
   1 SAVE "LISTING 8"
   2 LPRINT "LISTING 8",,,,
   3 LLIST 10
   4 LPRINT " GOTO 0"
   5 STOP
  10 LET F=SGN PI
  20 GOSUB CODE " COPY "
  25 IF F THEN PRINT "FUNCTION"
  30 INPUT A$
  35 IF F THEN PRINT "LOWER LIMI
T"
  40 INPUT X
  45 IF F THEN PRINT "UPPER LIMI
T"
  50 INPUT A
  60 LET K=X
  70 FAST
  80 IF F THEN CLS
  85 LET F=NOT PI
  90 LET DX=(A-X)/CODE "Z"
 100 LET H=VAL A$
 110 LET L=H
 120 FOR I=NOT PI TO CODE "Z"
 130 IF H<VAL A$ THEN LET H=VAL
A$
 140 IF L>VAL A$ THEN LET L=VAL
A$
 150 LET X=X+DX
 160 NEXT I
 170 LET X=K
 180 SLOW
 190 FOR I=NOT PI TO CODE "Z"
 200 PLOT I,VAL "43"*(VAL A$-L)/
(H-L)
 210 LET X=X+DX
 220 NEXT I
 230 GOSUB VAL "400"
 240 GOTO VAL "50"
 300 RAND USR RS
 310 FOR A=VAL "-2" TO VAL "10"
 320 FOR B=NOT PI TO VAL "24" ST
EP VAL "8"
 330 LET A$=""
 340 IF B OR A<NOT PI THEN RAND
USR RD
 350 IF NOT B AND A>-SGN PI THEN
 LET A$=STR$ A
 360 PRINT TAB B;A$;
 370 NEXT B
 380 NEXT A
 390 REM ***,SELECT,OPTION,***,O
PTION,FN,RANGE,, INPUT ,YOUR,OWN
 FN,
 400 INPUT B
 420 IF NOT B THEN RETURN
 430 RAND USR RS
 440 FOR A=SGN PI TO VAL "3*B+8"
 450 LET A$=""
 460 RAND USR RD
 470 NEXT A
 480 FOR A=-SGN PI TO SGN PI
 491 LET B$=""
 500 RAND USR RD
 510 IF A<NOT PI THEN LET A$=B$
 520 IF NOT A THEN LET X=VAL B$
 530 NEXT A
 540 LET A=VAL B$
 550 GOTO VAL "60"
1000 REM SIN X,0,2*PI,COS X,0,2*
PI,TAN X,-1,1,SIN X+SIN (2*X)+SI
N (3*X),0,4*PI,ASN X,-1,1,LN X,.
1,2.7,EXP X,-1,1,ABS (X-INT X-.5
),0,3,1/X,.1,2,EXP -(X*X),-2,2,
```

lower and upper limit. If you only have 1K RAM then you will not be able to use this feature. If this is the case, then enter the program without the USR routines in memory and omit lines 10, 20, 25, 35, 45, 80, 230, 300, and every line above 300.

You cannot plot more than one function on the screen at the same time, but none of the prompt messages will appear after the first graph. Prompt messages also do not appear on the 1K version described above.

I hope that these routines and programs are of use to you. If you have other ideas on how to extend the capabilities of this little computer in this way, drop a line to *SYNC*. ■

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