HiSoft BASIC

For ZX Spectrum, ZX Spectrum +, ZX Spectrum 128 & ZX Spectrum Plus 2

A Fast Floating-Point ZX BASIC Compiler

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Please buy, don't steal

HiSoft The Old School Greenfield Bedford MK45 5DE Tel (0525) 718181

HiSoft BASIC was written by Cameron Hayne

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Appendix 1 - Spectrum 128 version

Introduction

HiSoft BASIC is a BASIC compiler that surpasses all others for the Spectrum. There are integer compilers that can make Basic programs run more than 100 times faster but they only handle integers (no decimals, only whole numbers from - 32768 to 32767 or from 0 to 65535) and often have other restrictions. There are floating-point compilers that handle the full range of decimal numbers and all of the Spectrum's functions but (in spite of advertised claims) they speed up programs by only a factor of 3 to 5.

HiSoft BASIC combines the advantages of these two types of compilers without any of the disadvantages. It is a floating-point compiler that can obtain the speed of an integer compiler when doing operations that don't require the complexities of floating-point arithmetic. In fact, **HiSoft BASIC** is simultaneously the fastest integer compiler and the fastest floating-point compiler available for the Spectrums.

HiSoft BASIC can compile almost all of the Spectrum's BASIC into fast machine code. Unlike some floating-point compilers, it can handle user-defined functions and two-dimensional numeric and string arrays. Most other compilers have a block of routines about 5K in length (called *runtimes)* that must be present for the compiled code to work. This means that even the shortest BASIC program compiles to more than 5K. **HiSoft BASIC** includes only the runtime routines that are actually necessary for your code so that a short BASIC program may compile into only a few hundred bytes. Also, unlike other compilers, **HiSoft BASIC** allows you to put the compiled code anywhere in RAM you want, even in locations normally occupied by the compiler itself!

Spectrum 128 & Plus 2 Owners - Please Note

Spectrum 128 and Spectrum Plus 2 owners should read **Appendix 1** before using **HiSoft BASIC;** this describes the extra features available for these machines.

HiSoft BASIC is only about 11K in length so it loads quickly. It can compile BASIC programs up to about 30K in length without requiring microdrives or cumbersome tape swapping. Another distinguishing feature of **HiSoft BASIC** is that it provides full information on the code that it produces so that it is easy to interface the compiled code with a co-resident BASIC program. Or, if you're interested in machine code, you could use this information to learn how to use the ROM routines.

Finally, **HiSoft BASIC**, unlike many compilers, does not blindly follow a recipe in converting your BASIC to machine code. Instead, it watches for simple cases (e.g.: operations with powers of 2, constant array indices, etc) which it can compile into especially-efficient codes.

HiSoft BASIC is very easy to use but we recommend you read through this manual before starting any serious compiling.

Try this First

The instructions for using **HiSoft BASIC** follow this introductory section but instead of leaving you to read them and figure out things for yourself, we'll show you the ropes with a few example programs.

First load **HiSoft BASIC** by putting the tape with the words HiSoft BASIC uppermost in your tape recorder, typing:

LOAD "" [ENTER]

and pressing PLAY on your tape player.

When it is finished loading you'll see the copyright notice at the top of the screen. Then load in the first example program by typing:

LOAD "EXAMPLE 1" [ENTER]

LIST it and then RUN it to test it out and make sure that it works. This is a vital step before attempting to compile any program! As you might not always want to compile all parts of your BASIC program, it is necessary to tell **HiSoft BASIC** where to start and where to stop compiling. As with all instructions to **HiSoft BASIC** (called *compiler directives)* this is done via a REM statement. The *start-compiling* instruction is:

```
REM: OPEN #    (do this now by making this instruction line 1 of the example)
```

The *stop-compiling* instruction is:

```
REM: CLOSE #
```

but this is optional here since we want to compile right to the end of the BASIC.
Now type

*C

and compiling will start.

Users of Spectrum 128 and Spectrum Plus 2 computers should note that **HiSoft BASIC** commands are invoked in a totally different manner. Rather than typing * followed by a command letter, you should press the [TRUE VIDEO] and [INV VIDEO] keys simultaneously. This will produce a menu of command options on the screen from which any of the compiler commands may be selected.

During compilation, **HiSoft BASIC** will pause twice, showing some information at the bottom of the screen. You'll have to press a key to continue (don't worry about the information - you'll not need it now). The borders will change colour (magenta-cyan-white) and strange dots and colours will appear on the screen. We'll explain later what all this is; for now we just need the information that will appear after the second key press. For the first example program, this should indicate that the compiled code (machine code) is 357 bytes long and that 10 bytes must be reserved for machine-code variables (for the sake of comparison the number of bytes taken up by the BASIC program without variables is also given). The most vital information is in the two lines that tell you how to save and load the compiled code. The address in the LOAD line is the address to be used after RANDOMIZE USR when you want to execute the compiled code. E.g. if the code is to be loaded to address 65001 then RANDOMIZE USR 65001 will execute the compiled code. But while HiSoft BASIC is resident there's an easier way; *R will execute the compiled code. Spectrum 128 and Spectrum Plus 2 owners: remember that commands are invoked using [TRUE VIDEO] and (INV VIDEO] on your machines!

You can test out the machine code now if you like. By the way, don't be alarmed at the fact that this very small program seems to require so many bytes in machine code. Most of the bytes are taken up by the runtimes - subroutines that are included as needed but that will be re-used by other parts of a larger program. Thus the ratio of bytes used for machine code to those in the BASIC will decrease as the size of program increases.

Your BASIC program is still there after compilation and can be modified and re-compiled. Without changing anything, try compiling it a second time (with *C) just to see what happens. All the information on the final screen will be the same except for the address where the compiled code is located. Each time you compile a BASIC program, the compiled code is placed at what the Spectrum considers to be the top of your memory space (i.e. just below RAMTOP) and the RAMTOP is changed to be just before the newly-compiled code. To reclaim that memory (by resetting RAMTOP to its original value) type *X.

We want to use the first example program to illustrate that the variables used by BASIC and the variables used by the compiled code are totally distinct.

Re-compile the program (with *C). Now RUN the BASIC version and then, as a direct command, execute PRINT N1, N2. Now execute the machine code version (with *R), this time responding with different numbers than those you used for the BASIC version. Now re-execute the direct command PRINT N1,N2. The BASIC variables are still as they were. The machine code variables are local to the compiled code.

Before we leave this example, we must point out that the INPUT command is one that behaves slightly differently in the compiled code than it does in BASIC. The difference is in its response to errors. In BASIC, an error in input returns control to the editor with an error message. This would be inconvenient in machine code, so in the compiled code INPUT commands are error-trapped so that any error results in a restart of the INPUT. Test this out for yourself with the compiled code.

Now type:

LOAD "EXAMPLE 2" [ENTER]

and LIST it once it has loaded. Put in a new line:

```
9 REM: OPEN #
```

and RUN it to make sure it works, then compile (with *C). The thing we want to bring to your attention now is the number of bytes taken up by machine code variables. The total is 277; this is 15 bytes for the FOR/NEXT variable 1,5 bytes for L, and 257 bytes for N$. The 257 is made up of 2 bytes for the length of N$ and 255 bytes to hold the actual characters. Since no name is ever going to be that long, it seems wasteful to reserve that much space for it. By using the REM: LEN directive we can tell **HiSoft BASIC** how much space to reserve for a string variable. In this case suppose we decide that we are safe in assuming that no name could possibly ever be longer than 50 characters, then we can tell **HiSoft BASIC** this by inserting a new line:

```
8 REM: LEN N$ <=50
```

(on the 48K Spectrum the <= is the single character obtained by [SYMBOL SHIFT] -Q). Do this now and re-compile. You will see the number of bytes for machine code variables is now only 72 (52 bytes reserved for N$). It may seem that 50 is still too long, but it's better to err on the long side - too little space can be fatal. Incidentally, all this is necessary because we've chosen to opt for efficiency over convenience. In BASIC, when you assign to a string variable, the old copy is destroyed, all the other variables are shuffled down, and the new string is inserted at the end of the variables list. But this takes time! In the compiled code from **HiSoft BASIC**, all variables including string variables are at fixed locations, which gives a great improvement in speed. Note that for DiMensioned string variables, **HiSoft BASIC** can tell from the DIM statement how much space to reserve and so the REM: LEN directive is not necessary.

The first two example programs served to illustrate some essential points about using HiSoft BASIC but they weren't very interesting as programs and they certainly didn't show any perceptible increase in speed; and speed after all is what you're here for! So type:

LOAD "EXAMPLE 3" [ENTER]

and we'll start to explore the true capabilities of **HiSoft BASIC**. RUN the program as usual, to make sure it works (we emphasise that this is an essential step before attempting to compile any program). If you LIST the program you will find that we've already included the REM: OPEN # directive at the beginning so we're ready to compile. Type *C and watch. You will find that you get line 290 at the top of your screen with a flashing ? and the message Not supported at the bottom. What is not supported is the tape command

SAVE. None of the operating-system commands are supported by **HiSoft BASIC** because they are usually more appropriately left in BASIC. This is where the directive REM: CLOSE # is useful. Insert a new line:

```
271 REM: CLOSE #
```

and then re-compile. It will work this time. Try out the newly-compiled machine code and you will see the spiral drawn more than 3 times faster. A few asides on the program: note, in lines 20-50, that the values of the SIN and COS functions are computed only once and then assigned to variables for future use. As these functions (along with TAN, ASN, ACS, ATN, EXP, LN, SQR) are very slow, this is a smart thing to do whenever possible. Note also the CLS in line 15. This is redundant in BASIC since a CLS is done automatically when we RUN the program, but it is needed for the compiled code.

But what about the line 290 that was left out of the compilation? Since we now have a machine code version of the program, what we want is a BASIC loader program that looks like this:

```
10 CLEAR wwwww
20 LOAD "spiral" CODE xxxxx: RANDOMIZE USR xxxxx
30 STOP
40 SAVE "spiral" CODE xxxxx, yyy
```

where the xxxxx and yyy are the numbers given by **HiSoft BASIC** and wwwww is below xxxxx.
Now type:

```
LOAD "EXAMPLE 4" [ENTER]
```

and LIST it. You will see that it is the same as EXAMPLE 3 but with additional lines at the end. We've already put in the line 271 REM: CLOSE #. If you compile it as it is now, the compiled code would be precisely the same as that from EXAMPLE 3. The BASIC lines after 271 would simply be ignored (although they do figure in the number given by the **HiSoft BASIC** for the bytes taken up by BASIC). What line 1000 does is to POKE the picture on the screen into storage at memory address 45000; line 2000 recalls it from memory onto the screen.

Type *R and RUN the program. When the drawing is completed, execute GOTO 1000. After the STOP message (it will take a few minutes) execute CLS and then GOTO 2000. After another few minutes, the spiral will have reappeared on the screen, but since it takes several times longer to recall the spiral from memory than it would take simply to re-draw it, this seems pointless! But the compiled version will be faster! What we want in the compiled version is to have three separate entry points to the machine code: the first to draw the spiral and the second and third to store and recall it from memory. We already have the first entry point at REM: OPEN # and the return to BASIC occurs at the REM: CLOSE #.

We want additional entry points at lines 1000 and 2000, so we insert new lines:

```
 999 REM: OPEN #          and
1999 REM: OPEN #          (do this now)
```

The returns to BASIC from these sections of code will be from their STOP statements. There is no need for any additional REM: CLOSE # because we want to compile right to the end of the BASIC. Now we're ready to compile so type *C. This time you will be required repeatedly to press a key as information about the various entry points comes up on the bottom of the screen.

We will now explain what these numbers mean. During the first pass (with a cyan border) you will be told the relative addresses of the various entry points - i.e. relative to the start of the compiled code. During the second pass (with a white border) you will be told the execution addresses (in both decimal and hexadecimal) of the various entry points. Make a note of these for use later. Note also (from the final screen) the number of bytes taken up by the compiled code. Remember that if you miss some information

during compilation, you can always re-compile (after *X if desired). Now try out the compiled code by executing the first part to draw the spiral, then the second part to store it in memory, then CLS and finally execute the third part of the compiled code to recall the spiral screen. Note that *R works only for the first entry point. You should find that now it takes about the same time to recall the spiral from memory as it would to re-draw it.

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So our store and recall routine still doesn't seem very useful. But there's a further improvement we can make that will dramatically increase the speed. The key fact to notice is that the variables I, SOURCE, and DESTINATION of lines 1000-5040 take on only values that are positive integers (they range from 16384 to 51911). If **HiSoft BASIC** is informed of this fact (it's not quite smart enough to notice it for itself!), it will generate much more efficient code because it can then use the native abilities of the Z80 processor rather than relying on the ROM routines for floating-point arithmetic. The way to inform **HiSoft BASIC** is to use the directive REM: INT +. This directive must come before the first REM: OPEN #, so we insert a new line (do this now!):

```
9 REM: INT + I, SOURCE, DESTINATION
```

This tells **HiSoft BASIC** that these variables will take on only values that are positive integers in the range from 0 to 65535. We know this to be true for lines 1000 to 5040 but before we can re-compile we must check that it is true for the whole program. There is a variable i (which to the Spectrum is the same as variable I) in lines 130, 160, 230 but we easily can see that it too takes positive integer values in the right range. So go ahead and re-compile. You will notice that the new compiled code takes fewer bytes, but the real difference is in the speed.

Now it takes less than 0.7 seconds to recall a screen from memory! If you time it with a stopwatch you will also find a small decrease in the time taken to draw the spiral. There is no dramatic increase in the speed of drawing the spiral because most of the time is spent in the ROM DRAW routine.

We have just seen how much more efficient it is to use integer variables wherever possible. However, in this program it was relatively easy to convince ourselves that the variables I, SOURCE and DESTINATION take on only integer values. In other, more complex programs it may be more difficult to pick out the integer-valued variables. But help is at hand! Type *T. Nothing will happen right away. But now RUN the BASIC program. You should see the lower screen go BRIGHT and the spiral being drawn more slowly than usual.

When it's finished, type *T again and this time you will be rewarded with a list of variables. Beside each variable is the *type* of that variable: REAL, INTEG or POS INT (or POS INTEG - a combination of POS INT and INTEG). See below for an explanation of variable types but for now just note that variable i is listed as POS INTEG which means that its value never went out of the range of positive integers between 0 and 32767. The program STOPped at line 280 so what this is really telling us is that the variable i never goes out of that range in lines 130-230. The program has not yet explored the region of lines 1000-5040 so variables SOURCE and DESTINATION are not even listed yet. To get a full indication of the variable types we would have to execute the other two sections of the program separately, e.g. by doing the sequence:

```
*T
RUN
GOTO 1000
GOTO 2000
*T
```

If you don't find the long waiting times too irksome, you could try this now but otherwise you can just take our word for it that the variables I, SOURCE and DESTINATION would all come out listed as POSINT. All this is just confirmation of something that we realised earlier but you can see how it could be useful when applied to more complex programs. What *T does is to turn on another program that keeps watch over the values of the variables during the BASIC program's execution. The second *T turns this off and prints the

results. Anything you do between the *T's that affects the variables will be taken account of in the results. Thus, if you were to do the sequence: *T, RUN, LET i = 1.3, *T, the variable i could be shown as REAL instead of POSINTEG.

We must caution you that *T is not an infallible guide to the types of the variables. To illustrate this, first get rid of the existing BASIC by typing *ERASE (to get ERASE, go into extended mode then press [SYMBOL SHIFT] -7). Do not use NEW as that would wipe out **HiSoft BASIC** as well! Now type in the following program:

```
10 LET A=0
20 IF RND > .5 THEN LET A =.5
```

Do the sequence: *T, RUN, *T and then repeat this sequence a few times. You will notice that the variable A is listed sometimes as REAL, sometimes as POSINTEG. The reason for this is clear - there is a branch in the program depending on the value of RND and if RND < .5 the program doesn't realise that A is ever non-integral. The lesson you should draw from this is that, in using *T, you should repeat the program enough times with different inputs to make sure that the whole ojf the program is explored. In this example it would probably suffice to do: *T, RUN, RUN, RUN, RUN, *T.

Now type**:**

```
LOAD "EXAMPLE 5" [ENTER]
```

This program is ready to compile, but first LIST it and note the use of INT after the DATA command. The variables X and Y are READ from this DATA list and since they are declared to be of type POSINT by the REM: INT + directive, it is necessary that the data be stored in integer format. This is accomplished by putting an INT after the DATA. Compile and RUN this program at your leisure.

Now type:

```
LOAD "EXAMPLE 6" [ENTER]
```

and RUN it. You will see that it is a typical example of *menu programming.* Try to compile it and you will get line 50 at the top of your screen and the dreaded Not supported message at the bottom. Line 50 is what is called a *computed GOSUB* statement. The line number is not given explicitly but must be computed at run-time, so in order to compile such statements the compiler must make a list of all the line numbers and the corresponding addresses in the compiled code. The compiled code for the GOSUB will then search through this list at run time to find the address for the line number that is needed. **HiSoft BASIC** has the capability to do all this, but since it results in slower and longer code, we have made it a non-standard feature that you must select by means of a compiler directive.

Insert a new line:

```
7 REM: GOSUB:
```

and it will now compile correctly.

Note that the compiled code is 752 bytes long. If you look at the program you'll see that the variable N can be 1, 2 or 3, so the only line numbers we really need for use in line 50 are lines 100, 200 and 300. You can tell **HiSoft BASIC** this by changing line 7 to read

```
7 REM: GOSUB 100, 200, 300
```

and now if you recompile you'll find the code is 724 bytes long because we're now keeping only the info for those 3 lines rather than for all the lines of the program. For this short program it's not much of a saving, but for longer programs the savings in bytes can be enormous, and having a shorter list to search through can significantly increase the execution speed. To see what happens if you omit a relevant line number, delete the 300 from line 7, recompile, and try out the compiled code, selection option 3. Note also that if you change line 50 to GOSUB 100 *N-l, although it would still work in BASIC, the compiled code wouldn't work because lines 99, 199 and 299 don't exist.

The rest of the programs on the tape are ready to compile. You can LOAD and LIST them to see further examples of the use of compiler directives. The next program is called SIEVE and is a standard benchmark program. It finds all prime numbers less than twice the number used in line 20. As it stands, the program will not work in BASIC because there isn't room for an array of 8192 elements of 5 bytes each. However, the compiled version with the array f () declared as POSINT (so that each element only takes 2 bytes) works fine and takes only 2.9 seconds. Add a line:

```
165 PRINT prime
```

if you want to see the prime numbers (but this will slow it down a lot). To get the program to work in BASIC you will have to change both of the 8192s in line 20 to something like 7000 or smaller and RUN it on an otherwise empty Spectrum. With 7000 in line 20, the program takes 418 seconds to finish, compared with only 2.6 seconds for the compiled code - a speed increase of 161 times! If you try to compile this program twice in succession without resetting RAMTOP (by *X or CLEAR) in between, you will find that the addresses on the final screen after SAVE and LOAD differ from each other and you get a message DO NOT TEST on the bottom of the screen. This means that the code is not in its proper position and would have to be SAVEd and re-LOADed to its proper position before executing it. But beware of over-writing

The last two programs on the tape are SHELLSORT and QUICKSORT. Lines 9000 and higher of these two programs contain subroutines that sort an array X() of numbers into ascending order using two different algorithms. The rest of these programs are for testing the speed of these two algorithms in sorting data that is randomly arranged and data that is already in order. You will find that QUICKSORT is faster for randomly-arranged data but SHELLSORT is faster for data that are already almost all in order. The subroutines can easily be modified to sort into descending order or to sort strings instead of numbers. If you compile them, you will find that the compiled versions are up to 19 times faster!

How to Use HiSoft BASIC

1. LOAD "HiBasic" [ENTER]
(there are 3 parts which will load in sequence).

2. Either type in your BASIC program or LOAD it in from tape or microdrive (there is space for BASIC programs up to about 30K in length). Note: You must arrange your BASIC program so that it is possible to execute it by simply entering RUN (that is, it must start at the lowest line and all variables must be defined within the program). For example, if you have a BASIC program which you execute by entering RUN 9000 then insert a new line at the beginning that says GOTO 9000.

3. Make sure your BASIC doesn't include any of the commands or functions that aren't supported by **HiSoft BASIC** (see **Summary of differences from Spectrum BASIC).**

4. Insert a new line with the compiler directive REM: OPEN # at the beginning of your program. Other compiler directives are optional.

5. RUN your program to make sure that it works. Try it with different inputs to cover all the possibilities and test out all the branches of the program. The compiled code will be designed to reproduce the effect of the BASIC (except faster!), so if it doesn't work in BASIC, the compiled version won't work either and may even crash. Conversely, if your program works in BASIC, you can expect the compiled code to do the same. It is a good idea to SAVE your BASIC program before proceeding.

6. Compile by typing *C (see **HiSoft BASIC Commands**). Refer to Error messages if compilation stops with a message at the bottom of the screen.

7. SAVE the compiled code.

The compiled code is like any other machine code program. To execute it requires the command RANDOMIZE USR xxxxx where xxxxx is its address. The compiled code will return to BASIC at points where there was a STOP command or a REM: CLOSE # directive or if it reaches the end of the program. Note that you must CLEAR wwwww before LOADing in the code, where wwwww is any address less than xxxxx.

HiSoft BASIC Commands

Commands may be typed in upper or lower case. Execution of the command is immediate upon receipt of the final character (no [ENTER] is needed). If at any time these commands should stop being accepted, re-initialise the command interpreter by RANDOMIZE USR 23792. Spectrum 128 and Spectrum Plus 2 owners should read Appendix 1 first.

***C**

Starts compilation of the BASIC program. Compiles those portions of the BASIC between compiler directives REM: OPEN# and REM: CLOSE#. The compiled code is placed just below RAMTOP and RAMTOP is revised. The following information is given during the first pass: the relative addresses of the entry points to the code. During the second pass: the execution addresses of the entry points to the code (both in decimal and hexadecimal). Compilation pauses after these until you press a key. At completion:

- The number of bytes taken up by the compiled code
- The number of bytes needed for machine code variables
- The number of bytes occupied by the BASIC program
- The commands to be used to SAVE the compiled code and to LOAD it back in afterwards.

The final screen is also sent to the printer if one is connected. Other information is available by use of the compiler directives REM: LINE and REM: LIST

***X**

Does the same as the BASIC command CLEAR 65367 except it doesn't do a CLS or a RESTORE. That is, it sets RAMTOP to 65367 (just below the usual position of the user-defined graphics) and sets up the machine stack there. In the context of **HiSoft BASIC**, it effectively erases previously-compiled code and thus provides space for new code. Note that if you have some machine code in high memory that you want to preserve then don't use *x, instead CLEAR to just below your machine code.

***R**

Executes the newly-compiled code, starting from the first entry point. This command does the same as RANDOMIZE USR xxxxx where the address xxxxx is the one on the final screen (except that it doesn't affect the system variable SEED).

***T**

This command is used to find out information about the variables used in your BASIC program. This information can then be communicated to **HiSoft BASIC** by means of compiler directives, enabling the compiler to produce more efficient code. The command *T gives the *types* (see **Variables)** of the simple numeric variables used (no information is given on arrays). It also gives the maximum lengths attained by the simple string variables used. After you first type *T nothing will appear to have happened but an interrupt-driven program has been turned on and the BASIC variables have been CLEARed. From then on, until you type *T again, the interrupt-driven program polls the BASIC variables (except for arrays) and maintains a file of the variable names and types. The second *T displays this file and then deletes it. In between the two *Ts you can do anything you normally do in BASIC. The bottom of the screen will go BRIGHT to show that you are in *T mode. The normal procedure would be to RUN your BASIC program one or more times (with different inputs) so that the variables cover their whole range of values. There is a small possibility that *T may give incorrect results because it only looks at the variable every 1/50 of a second. For example, with the one-line program 10 LET 1=1: LET I=.5: LET 1=1, the sequence *T, RUN, *T will tell you that I is POSINTEG when clearly it should say REAL. So *T is not an infallible guide to the variable types, but for most programs it works wonderfully.

***ERASE**

Removes the BASIC program and variables from memory without affecting **HiSoft BASIC** or any machine code above RAMTOP (to get ERASE, get into extended mode, then press [SYMBOL SHIFT]-?). Note that this is drastically different from NEW which would eliminate **HiSoft BASIC** as well since it lies below RAMTOP). To prevent you from accidentally doing a NEW, it has been disabled (but if you really want to get rid of everything, type a colon and then NEW).

BREAK
Pressing both [SPACE] and [CAPS SHIFT] (the normal BREAK procedure) will stop whatever program is executing at the moment, including machine code programs. This means that you can try out the compiled version of your program and stop it at any point (note, however, that the compiled code, like most machine code programs, does not include any test for BREAK and so, when you are using the compiled code outside of **HiSoft BASIC**, there is no way to stop it before it returns to BASIC).

The following commands would normally be used only when directed to do so by **HiSoft BASIC:**

***D** As *C but stores only the code generated by the DATA statements.

***E** As *C but does not store the code generated by DATA statements, i.e. it stores all the code except that of DATA statements.

These two commands are used to break up a large program that includes DATA statements into two parts: the code proper and the data. It does not matter which of the two commands is done first but both must be done. A flashing D or E will appear on the final screen to remind you which part you have done. Unless you are using the REM: USR directive, you must reset RAMTOP after doing the first part (either *D or *E) so that it is the same for both parts in order that both parts will be designed for the same execution address. Thus a typical sequence would be: *X, *D, SAVE the data part, *X, *E, SAVE the code proper. Note that the two parts will form one continuous block of code in your final program and so, after you re-LOAD the code, you can SAVE it as one block if you desire.

Summary of differences from Spectrum BASIC

(See further comments in **Notes on compiled BASIC)**
1. No expressions (except VAL "number") are allowed in DIM or DATA statements.

2. If expressions (other than VAL "number") are to be allowed in GOTO, GOSUB or RESTORE statements, then the appropriate compiler directive must be used.

3. Arrays of three or more dimensions (e.g. X [I, J, K]) are not supported.

4. VAL stringvariable (e.g. VAL A$) is not supported, (but VAL "expression" is okay).

5. The system commands CLEAR, CONTINUE, ERASE, FORMAT, LIST, LLIST, LOAD, MERGE, MOVE, NEW, RESET, RUN, SAVE,VERIFY are not supported (but passing back and forth between BASIC and the compiled code is easy so you can incorporate these in your programs).

6. INPUT commands are automatically error-trapped.

7. BREAK is disabled.

8. The default attributes of PAPER 8; FLASH 8; BRIGHT 8 that BASIC uses for PLOT, DRAW and CIRCLE commands are not instituted in the compiled code.

9. The printing of a string that contains colour control codes may change the default attributes in subsequent PRINT statements.

Variables

HiSoft BASIC allows all of the variable names that BASIC does. The speed and storage space of the compiled code are (unlike in BASIC) the same whether you use long or short variable names so descriptive names are to be encouraged for readability. **HiSoft BASIC** supports numeric and string arrays of up to 2 dimensions. Ordinary string variables behave as in BASIC except that they must not exceed in length the amount of space reserved for them at compile time. By default this is 257 bytes (to allow a string of up to 255 characters, plus 2 bytes for the length) but it can be changed by means of the REM: LEN directive.

Variable Types:

The type of a variable is an indication of the range of values it may contain. In BASIC, variables are of two types: numeric and string. HiSoft BASIC has 3 numeric types as well as strings. The default type is REAL. Variables may be declared to be INTEG or POSINT in order to enable more efficient code to be generated (see **Compiler directives).** If you don't care that much about speed or the size of the compiled code you can just forget about the integer types and keep everything as REAL. All variables used in the compiled code are stored in their own area just after the code (not in the BASIC variables area).

REAL: This the same as the BASIC numeric type; i.e. REAL variables can take on all floating-point values between -1.7 E 38 and +1.7 E 38 (but note that the smallest non-zero positive number is 2.94 E-39). REAL variables take up 5 bytes and are stored in the same format as in BASIC.

INTEG: The values taken by an INTEG variable are restricted to integers (whole numbers) between -32768 and 32767 inclusive. INTEG variables take up 2 bytes of storage in the standard Z80 format (least significant byte first);

POSINT: The values taken by a POSINT variable are restricted to positive integers (whole numbers) between 0 and 65535 inclusive. POSINT variables take up 2 bytes of storage in the standard Z80 format (least significant byte first).

Note that the ranges of POSINT and INTEG variables overlap. If a variable takes on only integer values between 0 and 32767, you have the option of declaring it to be either POSINT or INTEG (*T will show such variables as POS INTEG). The storage locations of variables can be obtained by the use of directive REM: LIST. **Note** that the current length of an ordinary string variable (or the length of each string for a dimensioned string variable) is stored in the first two bytes of the space reserved for that string variable, followed by the text of the string (or strings).

Numerical Constants

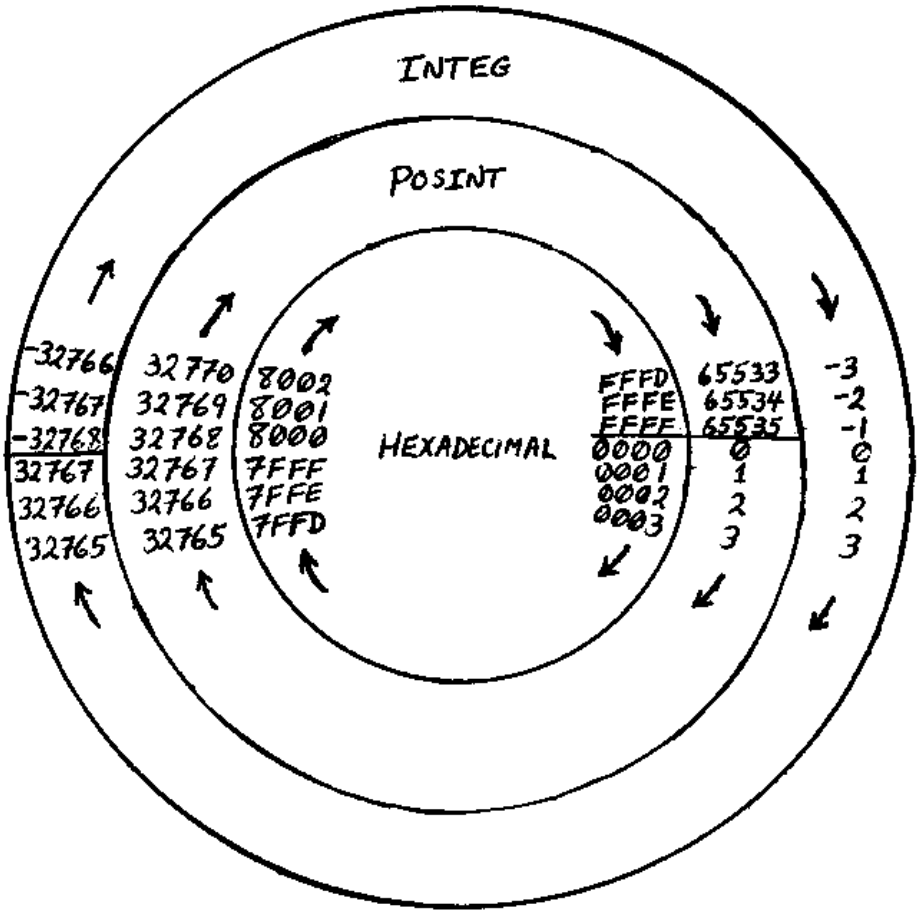
Numbers may be in ordinary or in scientific notation. For the purpose of storage format and evaluation of expressions, the type of a number is taken to be that of the range in which it falls (see **Variable Types**). The exception to this is if no INT or INT+ directives have been used. In this case all numbers are taken to be REAL and stored as 5 bytes.

Conversion between Types

REAL values are rounded to the nearest integer when a POSINT or INTEG value is required (error Integer out of range if bigger in absolute value than 65535).

Integer values (between -65535 and 65535) are converted to lie in the proper range for POSINT or INTEG types by adding or subtracting 65536 as appropriate. For example, if the value 40000 is assigned to INTEG

variable I, it will end up that I = 40000 -65536 = -25536, whereas if -40000 is assigned to I, it will end up that I = -40000 +65536 = +25536. If the value -3 is assigned to a POSINT variable P, it will end up that P = -3 +65536 = 65533. The logic of all this is shown by the diagram below which shows the different interpretations one can put (depending on type declaration) to a given internal representation of a number (shown in hexadecimal).



Compiler Directives

Compiler directives are a means of giving instructions to the compiler. Each compiler directive is of the form REM followed by a colon (:) followed by a Sinclair keyword and each must be on a separately-numbered line within the BASIC program to be compiled.

REM: OPEN #
Turns compilation on and inserts code to enable an entry from BASIC at this point.

REM: CLOSE #
Inserts code for a return to BASIC and turns compilation off. Optional if compilation right to the end of the BASIC is desired (note that this directive is equivalent to a STOP from the point of view of the compiled code although of course it has no effect on BASIC).

Note: The following compiler directives must precede (i.e. must have a lower line number than) the first REM: OPEN # .

REM: LEN
Tells **HiSoft BASIC** how much space to reserve for non-dimensioned string variables. If a string variable is used without being dimensioned or appearing in a REM: LEN directive, then the compiler will reserve space for 255 characters plus 2 bytes for the length of the string.
Examples of use:

```
REM: LEN D$<=5, F$<=704
```

would allow D$ to be up to 5 characters long and F$ to be up to 704 characters long (thus, including the 2 bytes for the length of the string, it would reserve 7 bytes for D$, 706 bytes for F$). Any other non-dimensioned string variable would have space reserved for 255 characters.

```
REM: LEN D$<=5, F$ <=704, $<=32
```

As before but any other non-dimensioned string variable is limited to 32 characters (there would be 7 bytes reserved for D$, 706 bytes reserved for F$ and 34 bytes reserved for any other). The $ without any letter changes the default max-length. The default max-length cannot be greater than 255. Note that LEN appears only once and that <= is the single symbol obtained by [SYMBOL SHIFT]-Q. Please note that if you declare for example that D$ will never be more than 5 characters long (as above) and then LET D$ = "MISTAKE", the extra characters will overwrite something else and the results will be unpredictable. So you should always reserve more space than will ever be needed. The use of *T can help you avoid counting.

REM: USR
Tells **HiSoft BASIC** where you want the compiled code to start. **HiSoft BASIC** always locates the compiled code at the top of memory (as given by RAMTOP) but the code can be designed to execute from any address you specify. If you don't include a REM: USR directive then the code will usually be designed to execute from where it is. If you do include a REM: OSR directive then the compiled code must be SAVEd and then re-LOADed to its proper address before you try to execute it. For example, REM: USR 30000 would make the compiled code executable from address 30000.

REM: INT
Tells **HiSoft BASIC** that certain variables will be of type INTEG. For example: REM: INT A, C, SCORE, A(), B tells HiSoft BASIC that the simple numeric variables A, C, SCORE and B will be of type INTEG and that the array A () will also be of type INTEG.

REM: INT+
Tells **HiSoft BASIC** that certain variables will be of type POSINT. For example: REM: INT + J, I, Level, K(), K tells HiSoft BASIC that the simple numeric variables J, I, LEVEL and K will be of type POSINT and that the array K() will also be of type POSINT.

REM: INT FN
Tells **HiSoft BASIC** that certain defined functions will return values restricted to integers in the range -32768 to 32767. For example, REM: INT FN A, T, B tells HiSoft BASIC that the defined-functions A, T and B will have INTEG values.

REM: INT+FN
Tells **HiSoft BASIC** that certain defined functions will return values restricted to positive integers in the range 0 to 65535. For example, REM: INT + FN N, I, p tells HiSoft BASIC that the defined-functions N, I and P will have POSINT values.

REM: FN(INT)
Tells **HiSoft BASIC** that certain one-letter variables are to be considered as type INTEG when used as dummy variables in a DEF FN statement. For example, REM: FN (INT A,B,C) tells HiSoft BASIC that the dummy variables A, B and C are to be considered of type INTEG in all DEF FN statements. Note that A, B and C might be a different type when they are not used as dummy variables.

REM: FN(INT +)
Tells **HiSoft BASIC** that certain one-letter variables are to be considered as type POSINT when used as dummy variables in a DEF FN statement. For example:

```
REM: FN(INT + I,J,K)
```

tells HiSoft BASIC that the dummy variables I, J, and K are to be considered of type POSINT in all DEF FN statements. Note that I, J and K might be a different type when they are not used as dummy variables.

REM: GOTO
REM: GOSUB
These two directives are completely equivalent. If you use either of them, then GOTO and GOSUB expression (e.g. GOTO 100 *N) will be supported and the compiled code will include a list of line numbers and the corresponding addresses in the compiled code. There are two forms: If the GOTO or GOSUB is followed by: (e.g. REM: GOTO:) then all of the program's line numbers within the region being compiled will be included in the list. If the GOTO or GOSUB is followed by a sequence of line numbers (e.g. REM: GOTO 100,200,300) then only those line numbers will be included in the list. In either case, if a line number not in the list is needed, the compiled code will generate a run time error *Statement lost*.

REM: RESTORE
If you use this directive then RESTORE expression (e.g. RESTORE 1000+N) will be supported and the compiled code will include a list of the line numbers of DATA statements and the corresponding addresses in the data area of the compiled code. The two forms of this directive (e.g. REM: RESTORE:and REM: RESTORE 1000, 1001, 1002) have a similar effect to those for REM: GOTO except that here only the line numbers of DATA statements are put in the list and the addresses are those in the data area of the compiled code.

REM: LIST
Tells **HiSoft BASIC** to produce a listing of the runtime routines used and the machine code variables. Addresses are given in both decimal and hexadecimal.

REM: LINE
Tells **HiSoft BASIC** to print the address of the compiled code for each line of BASIC starting at a given line number. During the first pass, the relative addresses are given, while during the second pass, execution addresses (in both decimal and hexadecimal) are given. For example REM: LINE 200 would result in the addresses being given starting with line 200. Note that this is just for interest - entry to the compiled code from BASIC should only occur at points with a REM: OPEN # directive.

REM: LPRINT

Switches output from LINE and LIST directives over to stream 3 (the printer). If this directive is used, **HiSoft BASIC** does not wait for you to press a key before continuing so you may want to use it even with no printer attached (or with it switched off) just to eliminate the waits for key presses in those cases where you are only interested in the information on the final screen.

Notes on compiled BASIC

The following notes explain the differences between Sinclair BASIC and compiled BASIC. They are somewhat technical and can often be ignored until a problem becomes evident.

Arithmetic Operators
(+,-,* and/)

1. If one of the operands is REAL, the other is convened to REAL if not so already.

2. Division (/) is the ordinary (floating point) operation (operands converted to REAL - not integer-division even if both operands are of integer type!). Thus 5/3 = 1.667 instead of the 1 you would get with integer-division (but see note 5 in Tips on Efficiency).

3. The minus sign (-), whether unary or binary, converts a POS I NT value into an INTEG value. ThusifPlandP2 are both of type POSINT, (P1-P2) is of type INTEG as is (-P2). Note that since POSINT can be as large as 65535 while the most negative INTEG is -32768, you can get some out-of-range values this way. No error message will be generated - you may just get some strange results (see **Conversion between Types**). So beware if you are subtracting POSINT values larger than 32768 (not that likely).

4. Apart from the exception of note 3, the type of the result from a sum, difference or product is the dominant type of the two types involved. REAL dominates both INTEG and POSINT while INTEG dominates POSINT. Thus, for example, if R, I, and P represent quantities of the types REAL, INTEG and POSINT respectively then (I*R) is of type REAL, while (I+P) is of type INTEG.

5. Because (P+I) and (I+P) are type INTEG, there may be a slight difficulty (similar to that of note 3) if the POSINT value is greater than 32767. For example, if P =65535 and l=-l, then you might expect (P+I) to be 65534 but since it is supposed to be INTEG, the value you would get (see **Conversion between types)** if you did PRINT (P+1) would be -2. Since -2 has the same internal representation as 65534 (it's only the type declarations that differentiate them!) this would be okay if you were using (P+I) to specify a memory address. A way out of all this confusion would be to use POSINTS greater than 32767 only for addresses or as FOR/NEXT loop variables where the difficulties are taken care of automatically. An alternative is always to assign such problematical expressions to a POSINT variable (if they are supposed to be positive) before using them. Thus: LET p=p+i: PRINT p gives 65534 as desired.

Comparison operators

1. If one of the operands is REAL, the other is converted to REAL if not so already.

2. The result of a comparison between REAL values is of type REAL. The results of all other comparisons are of type POSINT.

3. Note that if P is a POSINT quantity, p>=0 is always true, so something like LET p=p-l: IF p>=o THEN GOTO 100 doesn't make sense.

AND, OR

The result of these operations is of the same type as the first operand.

LET

When an expression is assigned to a variable, the value of that expression is automatically converted to the type appropriate for that variable. Error messages or erroneous results may be generated if you try to assign an out-of- range value to a variable. For example, suppose I and R are respectively INTEG and

REAL variables. LET R=I would (as you'd expect) give R the value of the variable I. LET I=R would round the value of R to the nearest integer before assigning it to I; e.g. if R=3.14 then I would be 3. If the value of R is bigger in absolute value than 65535 (so it won't fit in two bytes) you would get the error message *Integer out of range.* However, LET 1=40000.3 (a REAL value) or LET 1=40000 (a POSINT value) would generate no error message even though the value is too big for the INTEG range. Instead, the result would be that I would get the value -25536 (see **Conversion between Types**).

INPUT

1. INPUT statements are error-trapped and any error in input will result in a restart of the INPUT statement. This means that there is no way out of an INPUT statement other than giving input of the type requested.

2. The evaluation of numeric inputs is done via the BASIC VAL routine so expressions involving existing BASIC variables (as opposed to machine code variables) are accepted as input.

3. See the note under LET concerning out-of-range values.

FOR/NEXT

Be careful that, in a FOR/NEXT loop, the loop variable does not try to go out of range for its type. For example:

```
10 REM: INT + P
20 REM: OPEN #
30 FOR P=100 TO 0 STEP -1
40 body of loop
50 NEXT P
```

Here P is declared as POSINT (and there's nothing wrong with having a negative STEP value with a POSINT loop variable!) so that after what should be the last iteration (with P=0), the NEXT P statement tries to decrease P but instead of becoming -1, P becomes 65535 so the loop will never terminate. The problem lies in not recognising that loop variables always end up one STEP past their limit value.

GOTO, GOSUB

1. Unless one of the compiler directives REM: GOTO or REM: GOSUB is being used, the line number must be given explicitly as a number or as VAL "number".

2. The line referred to must actually exist within the portion of BASIC being compiled (if you have trouble with this, put in a REM statement with the appropriate line number).

RUN

RUN is not supported but it can be replaced by a GOTO the first line of your program. You may want to put in a CLS statement at the beginning.

RETURN

Be careful not to allow the execution of a RETURN from a subroutine without having done the corresponding GOSUB. This would cause an error *Return without GOSUB* in BASIC but it may crash the compiled code.

STOP

STOP causes a return to BASIC from the compiled code. **Note** that the REM: CLOSE # directive is effectively the same as a STOP from the point of view of the compiled code.

DIM

1. HiSoft BASIC supports both numeric and string arrays of up to 2 dimensions. The dimensions of the array as given in the DIM statement are fixed at compile time and must be given as explicit numbers or as VAL "number" (no expressions allowed).

2. The dimensions of an array must be the same throughout the program. That is, you cannot re-dimension an array with different numbers than those used in the first DIM.

3. You must not use a string variable as an ordinary string variable at the beginning of a program and then later change it to a dimensioned string variable with a DIM statement.

4. There are no checks within the compile code to ensure that an array index is within range.

CLEAR, CONTINUE, ERASE, FORMAT, LIST, LLIST, LOAD, MERGE, MOVE, NEW, RESET, SAVE, VERIFY

None of these system commands is supported by **HiSoft BASIC** but you can still use any of them by going back and forth between BASIC and the compiled code. These commands are often inappropriate or inconvenient in a purely machine code program.

VAL, VAL$

1. VAL$ is not supported (no great loss!).

2. VAL "Expression" is the only form that is supported. Here, Expression must be a numeric expression. The form VAL string variable (e.g. VAL A$) is not supported because to do so would have entailed either a great loss in efficiency overall or would have required the whole of the compiler to be present with the compiled code at execution time.

3. Sometimes the unsupported form VAL A$ can be replaced by a series of statements.

E.g.:
```
IF A$ = "1" THEN LET A = 1
IF A$ = "2" THEN LET A = 2
```

RESTORE, READ, DATA

1. On entry to the compiled code (at every REM: OPEN #) an automatic RESTORE is done to set the data-pointer to the first of the machine code DATA items.

2. Unless a REM: RESTORE directive is used, the line number is under the same restrictions as that of a GOTO.

3. If you READ from a DATA list into a POSINT or INTEG variable then that DATA list must be prefaced with INT (extended mode R) to tell **HiSoft BASIC** to store the data in integer format (2 bytes per number). For example:

```
10 REM: INT +X, Y, I
20 REM: OPEN #
30 FOR 1=1 TO 50
40 READ X, Y: PLOT X, Y
50 NEXT I
60 DATA INT 127, 87, 126, 85
70 DATA INT 26, 50, 29, 51
```

4. Only numbers, VAL "number" and explicit strings are allowed in DATA statements. Variables and other expressions in DATA statements are not supported. Instead of READing an expression into a variable you can do it (albeit less conveniently) by a direct LET statement.

5. The machine code data pointer is stored at 23660 in the space normally used for the BASIC system variable S-TOP.

PLOT, DRAW, CIRCLE

In BASIC, the commands PLOT, DRAW, and CIRCLE have as default attributes PAPER 8; FLASH 8; BRIGHT 8 so that the only attribute changed by these commands is the INK. For efficiency's sake, the setting of these default attributes is omitted in the compiled code. This means that (in the odd cases where it makes any difference) to get the same effect as in BASIC you would put these attributes in explicitly; e.g. PLOT PAPER 8; FLASH 8; BRIGHT 8; X, Y instead of merely PLOT X,Y. An artificial example of a case where it makes a difference is the following:

```
INK 6: PAPER 4: CLS: PAPER 7: PLOT 127, 87
```

DEFFN

If a defined function has more than 4 arguments, then the arguments must be all of the same type.

Including other machine code

A compiled program may call other machine code routines. Of course, the machine code must not overlap with the compiled code - use the REM: USR directive if necessary to avoid this. If you want to test the compiled code together with your other machine code while **HiSoft BASIC** is still present, then the other machine code must not overlap **HiSoft BASIC** (see **Memory Maps**). Note that machine code which relies on the structure of the BASIC program or the location of BASIC variables will not work when called from the compiled code (the same is true of POKES from BASIC, e.g. POKES to system variables NEWPPC and NSPPC). Note also that when **HiSoft BASIC** is present, BASIC programs are higher up in memory than usual.

Compiling large programs

Before compiling a large program, type *X to clear out any junk that may be cluttering high memory (in the extreme cases, where you need every last byte, it may be necessary to CLEAR 65535 and say goodbye to the user-defined graphics).

Note that by means of the REM = USR directive, the compiled code can be designed to start low enough (i.e. within the space now occupied by **HiSoft BASIC)** to allow you to still use other machine code and user-defined graphics in the final program (ifs just during the compilation process that we need the space).

If there is enough room below RAMTOP for the compiled code and the machine code variables then space is reserved for the machine code variables and the code can be tested in place. However, if there is space for only the compiled code, then the variables are omitted and the message DO NOT TEST is given. If **HiSoft BASIC** finds that there is not enough space below RAMTOP for the compiled code, it will check if there would be enough space if the BASIC program were deleted. If so, you will be asked for permission to delete the BASIC, and if you allow this, **HiSoft BASIC** will proceed to overwrite the BASIC with the compiled code.

If you are trying to compile a large program that includes DATA statements **HiSoft BASIC** may direct you to Use *D, *E. This means that it is not possible to compile the program in one go. You must use *D and *E to compile the data separately from the rest of the code (note that it is better to do the smaller of the two parts first to lessen the chance that the BASIC will have to be deleted and re-LOADed before doing the second pan. This usually means doing *D before *E).

If you get the message Not enough room for M/C and you haven't just refused permission to delete the BASIC, then you must somehow reduce the length of the compiled code to get it to fit. Using INTEG or POSINT variables instead of REAL can save a lot of bytes. Try to find out (by using REM: LINE) which parts of the program use the most bytes and replace as many statements as possible by GO SUBS to subroutines. Try to make your assignments to variables via READing from DATA statements instead of with LET. If you are using computed GOTO, GOSUB or RESTORE, then direct **HiSoft BASIC** to include in the list only those line numbers actually needed.

If your BASIC program breaks up naturally into independent parts (i.e. parts that don't share variables) then you could compile these parts separately. However, you should be aware that doing this involves a certain amount of duplication of runtime routines (just how much duplication can be ascertained by using the REM: LIST directive).

Tips on Efficiency

1. Use integer variables (POSINT or INTEG) wherever possible, especially in FOR/NEXT loops (POSINT FOR/NEXT loops are slightly more efficient than INTEG ones). Sometimes programs involving REAL variables can be re-written (perhaps by scaling everything up by a factor of 10000 etc.) to enable them to be expressed in terms of integer variables.

2. If you use defined functions, try to arrange it that their arguments are integer variables and that the function returns an integer value. Then tell **HiSoft BASIC** this by means of the appropriate compiler directives.

3. In expressions, try to put the simpler of the two operands on the right side of the operator. If you do this, **HiSoft BASIC** will be able to recognise many of the simple cases and code efficiently for them. For example, LET A=B*2 will result in far faster code than LET A=2*B because in the first case, **HiSoft BASIC** recognises the simple case of multiplications by two. A number is simpler than a simple numeric variable which is simpler than an array or a function (but note that an array indexed by a number (instead of a variable) is equivalent to a simple variable because **HiSoft BASIC** recognises this case and computes its address at compile-time). Some of the simple cases recognised by **HiSoft BASIC**:

-multiplication or division by a power of 2
-changing an integer variable by 1, 2 or 3
-operations with simple numeric variables (or array variables with constant indices)

Thus P+3 is better than 3+P
II + 12)*P is better than P*(II +12)
IF A (I) >P is better than IF P<A(I)

4. HiSoft BASIC recognises the two cases of squaring and cubing and codes to do these by means of multiplication rather than using the general to-a-power routine (which is very slow). That is, it effectively replaces *\cf1 }2 by x*x and x3* by x*x*x, however it does this in such a way as to generate more efficient code than if you were to make these replacements in the BASIC. Here x can be any quantity - not just a variable. Unfortunately, BASIC cannot cope with x2 or X if x is negative, so you often have to modify things (e.g. to (ABS X) 2) just to get the BASIC to work but otherwise it is best (from the point of view of efficiency in the compiled code) to leave it as X2.

5. As mentioned above (Notes **on compiled BASIC)** division is always considered as floating-point division. However, in one special case, **HiSoft BASIC** recognises that it can code for integer division and get the same answer as if it did floating-point division. This is the case where the division occurs inside an INT in the form INT (F1/F2) where Fl and F2 are both integer factors. Fl and F2 don't have to be variables, they can be complicated factors (e.g. (2+i2) 2) as long as they are either POSINT or INTEG But the expression inside the INT must be of the form of something divided by something else and nothing more. Thus INT (5 + F1/F2) and INT (F1/F2 + 5) would be coded using floating-point division while 5 + INT (F1/F2) would gain the advantage of integer division if Fl and F2 are integer factors Similarly, INT (5*F1/F2) would be coded using floating-point division but INT ((5 *F1) /F2) would gain the advantage of integer division. So if you want the truncated effect of integer division (or simply don't care about the fractional part of a division) put your divisions inside INT**. Note** that none of this affects the answer you get from a division - the compiled code will always give the same answers as BASIC - it just makes the compiled code more efficient. **Note** also that the use of the REM: LIST directive will tell you which form of division is being used.

6. If you assign a REAL value to an integer variable, the value is automatically rounded to the nearest integer. This means that in many cases, INT is redundant and inefficient. Note that this is often true in BASIC as well, since all the functions and commands that require integers automatically round values to the nearest integer.

7. In general, using strings is less efficient than using integer variables, so avoid using strings where possible. A common example is in testing to see which key is pressed. A poor way to do this would be (assuming we are in upper case; POKE 23658, 8 to ensure this):

```
IF INKEY$ = "A" THEN….
IF INKEY$ = "B" THEN….
```

Better is: `LET K = CODE INKEY$` (where K is POSINT)

```
IF K = CODE "A" THEN....
IF K = CODE "B" THEN....
```

because this avoids the repeated INKEY$. **HiSoft BASIC** recognises the form CODE "A" and converts this at compile time to the numeric code 65 but the CODE function does get in the way of other optimisations. An even more efficient way would be to find out (either from the appendix in the Spectrum manual or by PRINT CODE "A" etc.) what the numeric code for each letter is and use this (instead of CODE "A") in your program. Thus, best is:

```
LET K = CODE INKEY$
IF K = 65 THEN.....: REM "A"
IF K = 66 THEN.....: REM "B"
```

(But see note 11)

8. Even if you aren't using any integer variables you may want to declare a fake integer variable in order to save bytes. If you don't have any INT (F) or INT+ directives then all numbers that occur in the program will be stored in 5- byte format even if they are small integers. By declaring a fake integer variable (use a variable name not in use in your program) you will change this so that numbers are stored in 2 bytes where possible. But note that an arithmetic operation between 2-byte numbers is integer arithmetic so that PRINT 0-65535 would give I! (See **Conversion between Types**).

9. It is more efficient to put all numbers in the program in their decimal form E.g. use 0.5 or .5 or 5E-1 instead of 1/2 because the latter form would get coded as 1 divided by 2 and the division would have to be performed each time the number is used (this is also the case in BASIC).

10. To reduce the number of bytes taken up by the compiled code use subroutines as much as possible. If even the simplest statement is used more than once, it will save bytes if you make it a subroutine (but you lose a tiny bit of execution speed).

11. **HiSoft BASIC** recognises and codes efficiently for the common forms IF THEN GOTO and IF ..... THEN GOSUB..... in the cases where only one statement (the GOTO or the GOSUB) comes after the THEN. Multiple statements after the THEN negate these optimisations so

```
IF K=65 THEN GOSUB 1000: REM "A"
```

results in less efficient code than

```
IF K=65 THEN GOSUB 1000
```

12. If you are using computed GOTO, GOSUB or RESTORE statements (e.g. GOTO 100*N) then try to determine which lines are actually needed (e.g. if N is 1 2 or 3 then only lines 100, 200 and 300 are needed for the above example) and tell **HiSoft BASIC** this by means of the appropriate compiler directive This will save on bytes as well as making the compiled code run faster because there is a shorter list of line numbers to search through. Even if you are including all the line numbers (e.g. with REM: GOTO: directive) you can speed up the search for the most commonly used line number by including an additional directive with these commonly-used line numbers listed (e.g. if you have a REM: GOTO: directive but lines 3000 and

4000 are used frequently, then adding a REM: GOTO 3000, 4000 directive would be beneficial as then these line numbers would be put at the start of the list).

What if it doesn't work?

If the compiled code doesn't do what it is supposed to do, the first thing you should do is to remove all the compiler directives relating to integer variables (just putting another REM in front of them will effectively remove them). Then re-compile and try it again. If it works now, you will know that the problem was to do with an integer variable being assigned on out of range value or a DATA statement lacking an INT

If it still doesn't work, you should go back to the BASIC version of the program (always keep the BASIC version!) and RUN it, doing exactly the same things you did when trying the compiled version. If the BASIC version performs okay in the same situation then you probably have found a bug in the compiler! If you can, try to isolate the bug (i.e. find out which statement causes the problem) and write to us at the following address:

HiSoft
The Old School
Greenfield
BEDFORD
MK45 5DE

Error Messages

Invalid compiler directive

Check the section on compiler directives for the correct syntax. You will get this message if you try to declare a variable twice.

Expecting a number

See the appropriate command in **Notes on compiled BASIC.**

Expecting an integer

You have used INT at the beginning of a DATA statement in which there are non-integer values (see **Notes on compiled BASIC).**

Not supported

See the appropriate command in Notes **on compiled BASIC.**

Non-existent line

You have a GOTO, GOSUB or RESTORE referring to a line that is either non-existent or outside the region to be compiled.

Too many variables

The maximum number of simple numeric variables is 255.

No more space

This is a multi-purpose error message. If you are using one of the REM GOTO, GOSUB or RESTORE directives then you will get this message if storage of more than 450 line numbers is needed. Similarly, you may get this message with a GOTO, GOSUB or RESTORE followed by an explicit line number if there is no more space for storage of line numbers. If you get this message with an IF statement, it means that you have too many nested IFS (maximum is 10). If you get this message in reference to a variable, it means that there is no more space for storage of variable names. In this case you could remedy the situation by using shorter names.

*Use *D, *E*

See **Compiling large programs**

Not enough room for M/C

The compiled code will not fit in memory below RAMTOP. See **Compiling large programs**.

Exec.address too high

The execution address you have specified (by means of a REM: USR directive) does not leave room for the compiled code and its variables to fit in below RAMTOP. Perhaps RAMTOP can be raised (by means of CLEAR or *X) to enable the code to fit.

DO NOT TEST

This message is a warning to you that the compiled code is not in its proper position and hence you cannot execute it without first saving it and then re-LOADing it to its proper address. Note that the code in its proper position may overlap **HiSoft BASIC** (making **HiSoft BASIC** inoperable) - check the Memory Maps.

No file space

This message occurs during the use of the *T command if either there are too many variables (or too many long variable names) to fit in the allocated space (unlikely) or (more likely) if there is not enough space to create the file in the first place. The file takes up 2000 bytes in a fake BASIC line at the end of the program area. It is also possible that a BASIC error *Out of Memory* will be encountered during the execution of a BASIC program (while *T is in effect) because of the extra space taken up by the file.

The meaning of the dots and colours

HiSoft BASIC makes 3 passes through the BASIC. The *zeroth* pass with magenta border) checks merely for unsupported commands and picks out all the compiler directives and DIM statements. The *first* pass (with cyan border) is a dry run that determines how long the compiled code will be and locates the destination addresses of the GOTOs, GOSUBs, etc. The *second* pass (with white border) is when the actual machine code is generated.

During compilation, **HiSoft BASIC** uses the display file (the area of memory usually used to store the TV picture) to store its own variables and other information such as the files of BASIC variables and line references. This information appears as dots on your screen. Furthermore, the calculator stack and the machine stack are relocated to the attribute file (where the colours are stored) during compilation. The calculator stack appears at the top of your screen while the machine stack starts one third of the way from the bottom (these two stacks grow towards each other and **HiSoft BASIC** is headed for trouble if they meet!). So what you see in the changing colours is actually in some sense the compiler's thought process while the dots are its memory!

Making a back-up copy

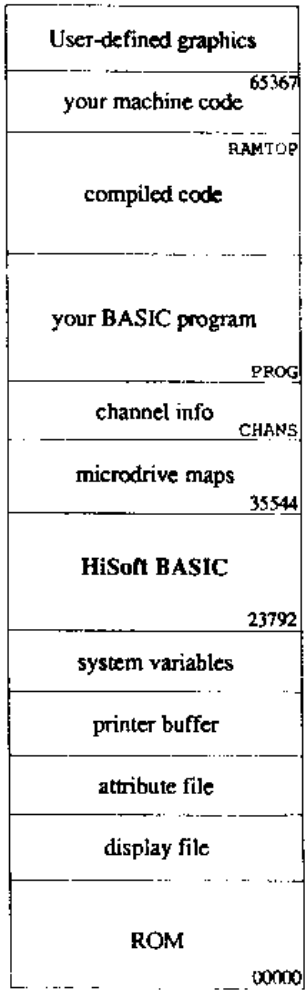
The facility for making a back-up copy is provided in the BASIC loader program. LOAD as usual but hold down the S key during the last part. When you hear the beep, prepare your new tape for recording and then press a key as required.

To transfer **HiSoft BASIC** to microdrive, follow the above procedure but BREAK into the program after the beep. Then modify it by inserting * "m"; d; after every SAVE and LOAD, where d is the drive number desired. Remove the -58, +58 from line 9999 and then finally GOTO 9999 will produce a microdrive copy. Modify the program in a similar way to obtain a back-up copy on disc. Note that owners of 128K machines do not need to delete the -58, +58.

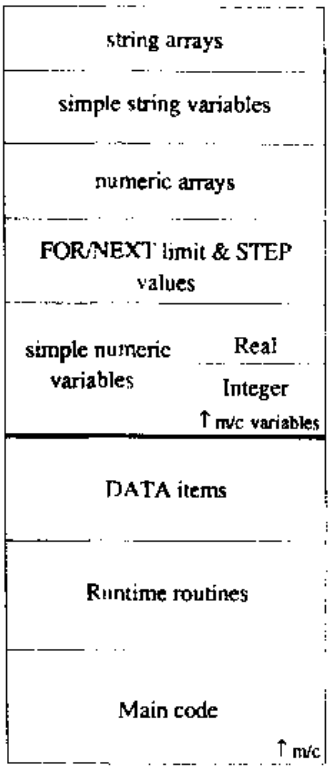
Over 2000 hours of hard work went into making **HiSoft BASIC** and every pirated copy steals away some of our rightful reward for this work. Ultimately, software piracy hurts you, the consumer, because prices go up or nasty copy-protection schemes are used and because programmers like ourselves will no longer find it rewarding to put the effort into writing good programs for your computer. If you somehow find yourself in possession of a pirated copy of **HiSoft BASIC** and you find it a good, useful program, then please do the honest thing and go out and buy yourself a legitimate copy!

Memory Maps

(These maps apply to the 48K Spectrum only)



At Compilation Time



At Run Time

Runtimes

The compiled code includes only those runtime routines that are actually needed. The REM: LIST directive will tell you which these are. In the following, p, I, R and S stand for POSINT, INTEG, REAL and STRING quantities respectively. Note that many runtimes call other runtimes. The first twenty-nine are concerned with comparisons.

1. I=P
2. P>=I
3. P>I
4. I<P
5. I< > P
6. P<=I
7. I>=P
8. I>P
9. P<I
10. I=P
11. I<=I
12. I>=I
13. continuation of 12
14. I>I
15. I<I
16. continuation of 15
17. P<=P
18. P>=P
19. P>P
20. P<P
21. P=P
22. P< >P
23. S>=S
24. S<=S
25. S<S
26. S>S
27. S< >S
28. S=S
29. Compare Strings
30. Print S
31. Print P
32. Print I
33. Single character of a string
34. String slicer (n1 TO)
35. String slicer(TO n2)
36. String slicer(n1 TO n2)
37. continuation of String slicer

38-46 not used

47. Print an explicit string
48. Calculate and stack parameters of an explicit string
49. Read string
50. Read integer (POSINT or INTEG)
51. Read REAL
52. On Error
53. Error handler
54. Exit from Input and Off Error

55. Pause
56. Set up Input
57. Input integer (POSINT or INTEG)
58. Input REAL
59. Input string
60. Get Input
61. Round a REAL into HL
62. USR string
63. USR number
64. Fetch integer array element
65. Fetch REAL array element
66. Calculate address of REAL array element
67. Fetch string parameters
68. Calculate parameters for a string from an array of strings
69. Assign to an unsliced string variable
70. Calculate and stack parameters for a simple string
71. Calculate parameters for a simple string
72. REAL comparisons
73. Copy a REAL from the calculators stack to (DE) but leave it on stack.

Runtimes 74-76 are concerned with REAL FOR/NEXT loops

74. Store STEP value and test loop
75. Increment loop variable and test loop
76. Test loop
77. R OR integer
78. R OR R
79. integer OR R
80. S AND integer
81. S AND R
82. R AND R
83. R AND integer
84. integer AND R
85. R*R
86. R/R
87. R*2 ^A (A is the value in the A register)
88. R^3
89. R + R
90. R - R
91. NOT integer
92. NOT R
93. -R
94. ABS R
95. SGN R
96. I DIV 2^B (DIV is integer division)
97. P DIV 2 ^B (B is the value in the B register)
98. P DIV I
99. I DIV P
100. l DIV I
101. continuation of 100
102. cube an integer
104. integer multiplication
105. ABS I
106. SGN I

107. SGN P
108. Move a REAL from the calculator stack to (DE)
109. Not used
110. Put the following 5 bytes onto the calculator stack
111. Put the POSINT value HL onto the calculator stack
112. Put the INTEG value HL onto the calculator stack
113. Exchange the top two values on the calculators stack
114. Set the printers for a binary operation
115. Test for zero
116. INK
117. PAPER
118. FLASH
119. BRIGHT
120. COURIER
121. OVER
122. AT
123. TAB
124. Set to Stream 2
125. Set to Stream 3
126. Memory fill
127. Random number generator
128. INKEY$
129. POINT
130. ATTR
131. CODE

Appendix 1
Spectrum 128 and Spectrum Plus 2 Version

There are a number of differences between the Spectrum 128/Spectrum Plus 2 and the 48K versions of **HiSoft BASIC**. The 128 version supports the PLAY command and the keypad, although the code it produces will run on any Spectrum, whether 48K or 128K (on a 48K machine, the PLAY code simply is ignored). The 128 version of **HiSoft BASIC** takes up fewer than 500 bytes of user memory since most of the compiler sits in the RAM disc. This means that it is possible to compile BASIC programs up to 40K in length.

The procedure for invoking **HiSoft BASIC** commands is different. If you press [TRUE VIDEO] and [INV VIDEO] simultaneously, a screen of command options will appear. The command you select will take effect immediately. Note that the options correspond to those for the 48K version but that there is a new P command, and that the command to delete the BASIC program is different.

The P command diverts the output of the next command to the printer (instead of the screen). Make sure your printer is attached and ready if you use this command. For example, press [TRUE VIDEO] and [INV VIDEO] simultaneously, then press P and then C to compile and send all information to the printer (or whatever is on stream 3).

The command interpreter in the 128 version is implemented by means of a patch to the bank-switching code instead of by an interrupt mode 2 routine as in the 48K version (thanks to Andrew Pennell for the idea of the patch). Because of this, it is not possible to BREAK into machine code programs as in the 48K version, so you should be sure to provide an exit from your program (e.g. IF INKEY$=S THEN STOP) before you test-run the compiled code. Note also that none of the addresses or pokes given above are relevant to the 128 version.

The compiler directives are the same as in the 48K version except that the L PRINT directive is absent; its function having been replaced by the p command. Note that the compiler will accept BASIC that has been prepared in either 48 or 128 mode, but that if you are typing in 128 mode the abbreviated directives OPEN and CLOSE (without the #) will be accepted.

It is worthy of note that if you are in the middle of editing a program line pressing [TRUE VIDEO] and [INV VIDEO] simultaneously followed by [ENTER] will return the line to what it was before. The effect is similar to that of the EDIT key when in 48K mode. Note also that it is useful to switch to the lower screen (via the 128 mode EDIT key) before compiling so that you can issue the command to SAVE your compiled code without the information disappearing from the final screen. Don't forget the usefulness of the SAVE ' and LOAD ! commands, especially when you get the DO NOT TEST message because the compiled code needs to be re-positioned.

An additional feature of the 128 version is that all of the extra editing keys on the optional keypad have been implemented on the standard keyboard (thanks to Toni Baker for her original program, which appeared in *ZX Computing Monthly).* These extra editing keys are described on page 7 of the 128 Manual In the following table TV, IV and SS represent [TRUE VIDEO], [INV VIDEO] and [SYMBOL SHIFT].

KEYPAD	KEYBOARD
← ←	IV and ←
→ →	IV and →
↑↑	IV and ↑
↓↓	IV and ↓
|← |←	TV and ←
→| →|	TV and →
↑↑	TV and ↑
↓↓	TV and ↓
DEL ←	SS and ←
DEL →	SS and →
DEL ← ←	IV, SS and ←
DEL → →	IV, SS and →
DEL |← |←	TV, SS and ←
DEL →| →|	TV, SS and →

Furthermore, the 128 version institutes a keyboard buffer which goes a long way towards solving the irritating problem of the missed keypresses when you start typing after a message has been displayed.