EXTENDED BASIC COMPILER

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The Extended BASIC language is arguably the most versatile of the languages available for the TI99/4A. Programs are easy to write, relatively understandable, and simple to modify and edit, with lots of error checking to facilitate program development. The main drawback is that the double interpreted nature of Extended BASIC makes it extremely slow.

The intent in writing my Extended BASIC compiler was to make it possible to take full advantage of the simple program development offered by XB, then make an end run around the speed limitations. The goal was to implement Extended BASIC as fully as possible within the time limits of the programmer and the memory limits of the machine. There *are* limitations and you will probably need to adjust your programming style a bit, but in general, all the major features of XB run the same when compiled. This means that you can concentrate on writing the XB code and testing it in the XB or XB256 environment. After the program has been perfected in Extended BASIC it can then be compiled into an equivalent code that functions at a speed approaching that of assembly language. The average Extended BASIC program will run at least 30 times faster after being compiled, and certain operations will run up to 70 times faster.

There are several methods by which the compiler achieves this speed increase. First, Extended BASIC must perform a lengthy prescan operation before a program can even start. This is done in advance by the compiler and becomes part of the compiled code. Second, an XB program is interpreted twice by the computer; once by the Extended BASIC interpreter, and a second time by the GPL interpreter. The compiler generates "threaded code" which needs its own interpreter (the runtime routines), but at least only one interpreter is involved, and it's a fast one! Third, integer arithmetic is used throughout instead of floating point arithmetic. This alone makes the code run at least 5 times faster, albeit without the versatility of 13 digit floating point accuracy. Fourth, to increase the speed even more, virtually no error trapping is done. Any error reports that are given are not very helpful anyway because you won't know the line number where the error happened. Therefore it is *imperative* that the Extended BASIC program be thoroughly debugged before you attempt to compile it!

The compiler has been expanded to include all the XB256 assembly language extensions except for CAT and SL2VDP. XB256 removes most of the graphics restrictions imposed by Extended BASIC. It lets you toggle between two independent screens. Screen1 is the graphics mode normally used by Extended BASIC; Screen2 lets you define 256 characters, more than double the number normally usable in XB. When in screen2, you can use up to 28 double sized sprites using the patterns available to Screen1. You can scroll screen characters left, right, up, or down and specify a window area for scrolling, leaving the rest of the screen unchanged. Other routines let you scroll smoothly one pixel at a time to the left, right, up or down. There are miscellaneous subroutines that let you hilight text, set the sprite early clock, print in any direction on the screen using all 32 columns, read from or write to the VDP RAM, write compressed strings to VDP, move sound tables into VDP, and more. With XB256 you can test your program in the XB environment, then use the compiler to get a huge performance increase. Once compiled an XB256 program is stand alone. It does not need XB256 to run.

The compiler is part of the XB Game Developer's Package. This is designed to work with Mike Brent's Classic99 emulator which is an easy, fast and powerful development tool. It eliminates many of the annoyances that come when you are running on a real TI99, such as slowness, limited room in the disk drives, difficulty in reading text files, etc. Follow the directions in *Using XBGDP* to set up the Game Developer's Package on your equipment.

The steps you need to follow in developing, compiling, assembling, and loading an XB or XB256 program are described in *Using XBGDP*.

The rest of this manual will describe the compiler, what instructions are supported, etc.

Starting at page 13, there is a section that describes how to use Asm994a, which is one of the cross assemblers available for the TI99.

If the program being compiled was written in TI BASIC, it is possible to use the runtime routines from the original TI BASIC compiler. This is limited to BASIC only, but it generates programs that are more compact and a wee bit faster than those created by the newer compiler. This is described starting at page 17.

Differences from Extended BASIC

An ideal compiler would be able to take any Extended BASIC program and compile it with no changes necessary so that it would run exactly the same only faster. This compiler falls short of that ideal, but does come close.

Following is a short overview of the differences between the compiler and Extended BASIC.

The biggest difference that you will have to deal with is that all numbers are integers from -32768 to 32767.
Here are some examples showing how the compiled code differs from the XB code:

32767+1=32768 in BASIC
32767+1=-32768 in the compiled code
200*200=40000 in BASIC; -25536 in compiled code because of the integer arithmetic.

If an operation such as dividing or SQR can give a non integer result, then you should use INT in the BASIC program to be sure that the BASIC and compiled programs function the same.

In Extended BASIC, RND returns a number between 0 and 1, so the INT of RND is always 0. Because of this, the following line of code won't work properly in the compiled code:.

```
10 IF RND>.5 THEN 100 ELSE 200
```

There is a work around built into the compiler that deals with this problem. You have to multiply the RND by some number and then INT the result. Instead of the example above you should use:

```
10 IF INT(RND*2)=1 THEN 100 ELSE 200
```

This gives either a 0 or a 1 in both Extended BASIC and the compiled code.

The timing of delays loops has to be modified. FOR I=1 TO 500::NEXT I gives a delay of several seconds in XB or BASIC; a fraction of a second in the compiled code. One way to have the same delay in both compiled and XB programs is to use CALL SOUND. For a 2 second delay you would use CALL SOUND(2000,110,30)::CALL SOUND(1,110,30). Neither XB nor the compiler can process the second call sound until the first has finished, so you get the full 2 second delay whether in XB or compiled code. Another way is to use CALL LINK(“DELAY”,2000) in XB256.

IF-THEN-ELSE now can use the more versatile Extended BASIC format, Earlier there were some limitations when using complex IF-THEN-ELSE statements. Those restrictions no longer apply.

User subprograms are fully supported with this difference: when using subprograms, the compiler will shorten the name to the first 6 letters. You can use longer names as long as the first six letters do not duplicate another subprogram. CALL UPDATEWHITE and CALL UPDATEBLACK would not compile properly. CALL UPDATWHITE and CALL UPDATBLACK would be fine, as the compiler sees them as UPDATW and UPDATB

Trig functions, LOG and DEF are not supported.

Assembly language subroutines cannot be used except for those included in XB256.

Supported Instructions

Following is a list of the TI Extended BASIC operations supported by the compiler:

Multiple statement lines can be used, with the statements separated with a double colon.

The arithmetic operators + - * / ^ work as they do in XB within the limits of integer arithmetic. Parentheses can be used to change the mathematical hierarchy used to evaluate expressions. Remember that because of the integer arithmetic, dividing 5/2 will give 2, not 2.5. You can use INT in the XB program when dividing (for example INT(5/2) to be certain that XB and the compiler give the same results.

The logic operators NOT, AND, XOR, OR work the same as in XB.

The relational operators < > = <> <= >= work the same as in XB.

ABS
ASC
CHR$
DATA *But you cannot GOTO a DATA statement*
END
FOR-TO-STEP As in XB, the step is optional; +1 is assumed if no step is specified.
GOSUB and GO SUB
GOTO and GO TO *But do not GOTO a DATA statement*
INT
LEN
LET – is optional just like in XB
MAX
MIN
NEXT
ON-GOSUB and ON-GO SUB
ON-GOTO and ON-GO TO
POS
READ
RESTORE *But RESTORE cannot point to a comment; it* must *point to a DATA statement*
RETURN
RPT$ – the string is truncated if over 255 characters and no warning is given.
SEG$
SGN
SQR – gives same number as INT(SQR(N)) in XB
STOP
STR$
SUB only the first 6 letters of the subprogram name are used.
SUBEND
SUBEXIT
VAL

RANDOMIZE can be used, but has no effect; it is done automatically
Integer arithmetic causes RND returns a value of 0. RND is only useful when it is multiplied by another number. i.e. INT(RND*6) gives the same results (0,1,2,3,4,5) when compiled as it does when used in XB. The order is not important – it can be (RND*6) or (6*RND)

String concatenation (i.e. A$&B$) works the same as in XB. The string is truncated if over 255 characters but no warning is given.

IF-THEN-ELSE now can use the more versatile Extended BASIC format.

INPUT works almost exactly like in XB, with the following differences. You can use the optional prompt. You can input more than one variable, but you must use the optional prompt to do this, even if it is just a question mark.. If inputting more than one variable, data being inputted is separated by the first comma the compiler comes to. Quotation marks will not behave as they do in XB. Rather, they are simply input as part of the string. You cannot use quotation marks to input leading or trailing spaces.
LINPUT works exactly like in XB.
ACCEPT works almost exactly like it does in XB. AT, BEEP, ERASE ALL, SIZE and VALIDATE are all supported with one difference: VALIDATE requires that you provide a string expression., which can be numbers, upper case characters, etc. UALPHA, DIGIT, NUMERIC are not supported.

PRINT works like TI Extended BASIC. You can use TAB, commas, semicolons and colons. *Do not print more than 20 variables in a print statement.* See page 7 for more information.

DISPLAY works just like in XB. You can use AT(row,col), BEEP, ERASE ALL, and SIZE(length) as well as TAB, commas, semicolons and colons. DISPLAY USING is not supported. (An XB trick to save memory is to use DISPLAY ERASE ALL to clear the screen. This crashes the compiler which expects DISPLAY to actually display something. Use CALL CLEAR if you just want to clear the screen.) With SIZE, using a print list with more than one element will cause the line to be cleared to column 28. If that is a problem, you can avoid it by concatenating and displaying a single string.

DIM and OPTION BASE are optional, as is in XB, but using them can reduce the size of the compiled program.

ARRAYS: Nexted arrays can now be used. If you have the two arrays DIM A(10),DIM B(10); you can now nest the arrays like this: Q=A(B(7))

Multiple variables can be assigned in a LET statement. Lines like these are now permissible:

```
10 A$,B$,C$="Hello World"
10 IF Z=7 THEN A,B,C=3
```

Error Messages

Although virtually no error checking is done, there are three conditions that can cause an error message to be issued. This can only happen when running the compiled program in XB and when using 24K of memory. Running in EA5 or in XB using 32K of memory will simply "quit" if the compiled program encounters these errors.

"BAD ARGUMENT IN 10" - issued if you take the SQR of a negative number.
"DATA ERROR IN 10" - issued if you read past the last DATA statement.
"MEMORY FULL IN 10" - issued if you run out of memory.

The following CALL subprograms function just like in Extended BASIC except as noted:

CALL CHAR
CALL CHARPAT
CALL CHARSET
CALL CLEAR
CALL COINC
CALL COLOR
CALL DELSPRITE
CALL DISTANCE
CALL GCHAR
CALL HCHAR
CALL JOYST – Both JOYST and KEY use the same internal keyscan routine.
CALL KEY – If KEY immediately follows JOYST, they will share one keyscan which is a bit faster. The key units must match. `10 CALL JOYST(1,X,Y)::CALL KEY(1,K,S)`
If KEY *does not* immediately follow JOYST then each does its own keyscan as in XB.
CALL LINK – only works with the assembly language subroutines provided by XB256.
CALL LOAD – can only be used to load values in RAM. Will not load assembly subroutines.
CALL LOCATE
CALL MAGNIFY
CALL MOTION
CALL PATTERN
CALL PEEK
CALL POSITION
CALL SAY – some minor limitations. See page 11 for more information.
CALL SCREEN – saves the screen color like CALL LINK("SCREEN") in XB256
CALL SOUND – cannot handle frequencies greater than 32767. (Neither can my ears!)
CALL SPGET
CALL SPRITE
CALL VCHAR
CALL (user defined subprogram) Only the first six letters of the subprogram name are used. Some names are reserved for the compiler. The table on page 12 has a list of these.

All the assembly language subroutines in XB256 are supported except for CAT and the IV254 utilities RUN, RUNL1, and SAVEIV.

REM and ! – All remarks are removed from the compiled program, but you can GOTO a REM statement just like in XB. Use of REM will not increase the size of the compiled program. (Remember that RESTORE cannot point to a remark; it must point to a DATA statement.)

Peripheral access is now supported for DISPLAY, VARIABLE files. See page 13 for more information.

From the command mode in Extended BASIC:
CALL LINK("RUN") functions the same as RUN in XB. You cannot use RUN or RUN line # within a compiled program. The compiler will change RUN to STOP
CALL LINK("CON") functions the same as CON in XB

<FCTN 4> breaks the program as in XB except during INPUT or ACCEPT. <FCTN 4> has no effect when running in EA5.

NOT SUPPORTED:

ATN
COS
DEF a line with DEF will be omitted by the compiler
DISPLAY USING
EXP
LOG
RUN or RUN line #.- use CALL LINK("RUN") if running the compiled program from XB.
If the compiler finds RUN in the XB program it will substitute STOP. When running from XB, STOP makes the compiled program return to XB. When running in EA5, STOP returns to the master title screen.
SIN
TAN

The following have no meaning in a compiled program:

BREAK
CON – use CALL LINK("CON") if running the compiled program from XB.
EDIT
LIST
NUM
RES
TRACE
UNBREAK
UNTRACE

The compiler uses a string that can be up to 255 bytes long for processing lines of code. This is almost always large enough..However, too many semicolons, commas or colons in a PRINT statement can cause the compiler to generate a string longer than 255 bytes. Although the compiler does not crash, the line is truncated and the code generated will not run properly.

```
10 PRINT A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,V,W
```

This compiles properly, but adding one more variable will be too long. You should be safe as long as there are no more than 20 variables in a print statement.

Embedding SINE values in a string:

Due to the integer arithmetic, trig functions are not supported by the compiler. However, there is a way to use them in a program. You can produce a 91 byte long MERGE format program line that contains a string with the values for sine from 0 to 90 degrees multiplied by 255, then use SEG$ to extract the sine value for any degree from 0 to 90 and convert it to a number with ASC. Such a string would contain characters that cannot be input from the keyboard, so we have to use a program to generate it.

A program can be used to generate a merge format file consisting of just one line:

10000 S$="a string containing 91 values for sine from 0 to 90, multiplied by 255"

Here is the program:

```
10 OPEN #1:"DSK3.SINE255",DI
SPLAY ,VARIABLE 163,OUTPUT
19 A$=CHR$(39)&CHR$(16)&CHR$          Line number - 39*256+16=10000
(83)&CHR$(36)&CHR$(190)&CHR$          S$ and =
(199)&CHR$(91)                        string constant; length of string
20 FOR ANGLE =0 TO 90
40 SINE=INT(255*SIN(ANGLE*PI          convert from radians to degrees and multiply
/180)+.5)                             by 255
50 A$=A$&CHR$(SINE)                   keep building string
80 NEXT ANGLE
90 A$=A$&CHR$(0)                      a zero at the end of the string
100 PRINT #1:A$
105 A$=CHR$(255)&CHR$(255)::
 PRINT #1:A$::PRINT #1:A$             Write >FFFF twice to write EOF
110 CLOSE #1
```

Let's say you wanted to launch a sprite with a velocity (VEL) and at an angle(ANG) between 0 and 90 degrees. (0 degrees is to the right, 90 degrees is straight up)
The column velocity (CVEL) is given by: VEL*COS(30) and the row velocity (RVEL) is given by: -VEL*SIN(30). But what do we do about the missing cosine functions? Well, it turns out that COS(angle) is the same as SIN(90-angle), which gives us a solution:

Run the above program, type NEW, then merge SINE255. Then add line 10010 to get the following subroutine:

```
10000 S$="a string containin
g 91 values for sine from 0 t
o 90, multiplied by 255"
10010 RVEL=INT(-VEL*ASC(SEG$
(S$,ANG+1,1))/255):: CVEL=IN
T(VEL*ASC(SEG$(S$,91-ANG,1))
/255):: RETURN
```

Save this in MERGE format for future use. You would call this from an XB program like this:

```
10 VEL=50::ANG=53::GOSUB 10000::CALL MOTION(#1,RVEL,CVEL)
```

The above subroutine is included on the compiler disk under the file name "SINE255"

The program above beginning with 10 OPEN #1 should have enough comments to give you ideas on how to write something similar that can generate strings containing character definitions, sprite data, or sound lists. You should know that the strings generated contain characters that cannot be input from the keyboard. These will run fine, but XB will complain if you try to edit the line. Besides speed, one advantage to using a string like this for defining characters is that the string is more compact. It uses 8 bytes per character while the normal CALL CHAR uses 16 bytes per character. But you lose the ability to easily edit the line or even to understand what is in it. The COMPRESS utility in XB256 automates the creation of this type of DATA line.

Disk Access

Disk and other peripheral access is now supported with some limitations:
DISPLAY, VARIABLE is the only file type recognized, but you can use any length desired from DV1 to DV254.

Up to three files can be open at a time. You must use #1, #2, or #3 – do not use other file numbers.

You can only use colons in a print statement. Commas and semicolons will not save as in XB.
10 PRINT #1:"Now, is, the, time " will print the entire string contained in the quotes.
20 PRINT #2:"Hello":"World" or 20 PRINT #2:"Hello"::PRINT #2:"World" are equivalent.
Use LINPUT for reading strings – INPUT will be treated as LINPUT if used
LINPUT will read the entire entry including any ASCII characters (like in XB)
Use INPUT for reading numbers (like in XB)
Specify INPUT or OUTPUT when opening a peripheral for reading or writing files.

Error checking with peripherals

Error checking should be set up just like in XB with the following limitations:

ON ERROR line number - transfers control to the desired line number
If you are not using ON ERROR and an error is encountered:
-If running from an XB loader, the program will end and return to the line editor. No disk error message is printed.
-If running as an EA5 program the program will return to the master title screen.

RETURN line number – this only works to return to a specific line number. Do not use RETURN or RETURN NEXT

Other peripheral devices should work if they can use DISPLAY VARIABLE format.

MODIFYING THE XB LOADER

EA5 programs cannot be changed, but there are modifications you can make to the XB program created by the loader. It consists of one XB line followed by the compiled program embedded in a way that is is invisible to the user. Here is the line of XB code:
10 CALL INIT :: CALL LOAD(8192,255,158):: CALL LINK("RUN")
This is a legal XB line which can be modified as desired by adding a comment or any legal XB command. You can add additional lines of code if desired, as long as you do not resequence the program..

If you want to pass a value, such as the timing for a loop, you can add to line 10 **CALL LOAD(16383,VALUE)::**CALL INIT etc. When the compiled program runs the first thing it does should be CALL PEEK(16383,VALUE) and now VALUE is available to the compiled program.

When running from XB, the compiled program is treated as a giant assembly language subroutine, invoked by CALL LINK("RUN"). When the compiled program ends or F4 is pressed, control is returned to XB. To to pass a value back to XB the compiled program can CALL LOAD(16383,VALUE). You would add to the loader: 20 CALL PEEK(16383,VALUE). When the compiled program ends, control returns to XB which executes line 20 and retrieves the value placed there by the compiled program.

With CALL LOAD and CALL PEEK you can easily pass values from XB to a compiled program, from a compiled program back to XB, or from a compiled program to a chained compiled program. When the entire compiled program is in high memory, addresses from 9728 to 16383 are available. When the runtime routines are in low memory, the amount of free memory depends on how many extras (XB256, Star Wars text crawl, lower case with descenders, disk access, speech.) you use. The loader reports what addresses are safe to use.

You can also use CALL HCHAR to store a value and CALL GCHAR to retrieve it.

Besides RUN there are two other options for starting the compiled program.

CALL LINK("RUNEA") - The compiled program behaves exactly the same as if you were running from EA5. The character sets are loaded and the colors are set. The only real difference is that no F4 scan is performed, so you can't accidentally break the program, and it will run a *very* tiny bit faster.

When RUN is performed, one of the things it does is to initialize the XB256 screen2 by loading the standard character patterns and colors, and then it starts the compiled program. If you are chaining compiled programs and wish to preserve the Screen2 graphics you can:

CALL LINK("RUNV") - This starts the compiled program just like RUN without initializing the Screen2 graphics.

HOW TO CHAIN COMPILED PROGRAMS

Here's a ridiculously simple program that chains to another equally simple program:

```
10 PRINT "Program One"::RUN "DSK1.PROGRAM2"        (saved as PROGRAM1)
10 PRINT "Program Two"                             (saved as PROGRAM2)
```

Is there any way to do the same thing in a compiled program? Not directly, because RUN cannot be used within the compiled code. But there *is* a way to do it. Here is a quick demonstration of how to do this. Compile these two programs:

```
10 PRINT "Program One"          (compiled and saved as PROGRAM1-X)
10 PRINT "Program Two"          (compiled and saved as PROGRAM2-X)
```

Now add line 20 to the XB portion of PROGRAM1-X

```
10 CALL INIT :: CALL LOAD(8192,255,158):: CALL LINK("RUN")
20 RUN "DSK1.PROGRAM2-X"
```

When the compiled PROGRAM1 ends, it returns to XB. Since the XB program is still running, it goes on to the next instruction which is RUN "DSK1.PROGRAM2-X"

If PROGRAM1 modifies the screen2 screen, character patterns, or colors and you want to preserve them in PROGRAM2, then you should change line 10 of PROGRAM2-X from CALL LINK("RUN") to CALL LINK("RUNV"). Also, to avoid scrambling screen2, PROGRAM2-X must be saved in IV254 format. Long programs do this by default, but if it is shorter than about 13K, first save PROGRAM2-X normally, then start up XB256 and type:

```
OLD DSK1.PROGRAM2-X
CALL LINK("SAVEIV","DSK1.PROGRAM2-X")
```

ADJUSTING THE TIMING IN A GAME PROGRAM

One frustration in developing an XB program intended for compilation is that is can be rather tedious to adjust the speed of the gameplay. You try a value in a FOR/NEXT loop, save the program, compile, assemble, load, only to find that it is too fast. Then you go back to XB, try a larger value, repeat the process; find that it is still too fast, try another value, etc, etc.

If you are using XB256 to develop the game there is an easy way to streamline the process. Let's say you are working in screen2. All you have to do is set up a “hot key” to go to a diagnostic menu in screen1, where variables can be modified without disturbing screen2. When done simply return to screen2 and resume where you left off.

In the simple demo program below, lines 100-200 define a ball and put it on the screen. The ball can be moved with the ESDX keys. If you press <Fctn 1> line 160 will go to line 210 where the delay value can be modified. After pressing <Enter> control returns to the main program loop with the modified delay value.

```
100 CALL LINK("CHAR2",65,"3C7EFFFFFFFF7E3C"):: R=12 :: C=16 :: DLY=1
110 CALL LINK("SCRN2")
120 CALL HCHAR(R,C,65)
130 FOR I=1 TO DLY
140 CALL KEY(0,K,S):: IF S=1 THEN 160
150 NEXT I
160 IF K=3 THEN 210
170 RN=R-(K=69)*(R>1)+(K=88)*(R<24):: CN=C-(K=83)*(C>1)+(K=68)*(C<32)
190 IF RN=R AND CN=C THEN 130
200 CALL HCHAR(R,C,32):: R=RN :: C=CN :: GOTO 120
210 CALL LINK("SCRN1"):: CALL CLEAR :: INPUT "DELAY VALUE? ":DLY :: GOTO 110
```

SPEECH

Speech has been added to the compiler. CALL SPGET works exactly like it does in XB. There are some minor differences in CALL SAY. The syntax is a bit more restrictive. Do not use leading spaces; only use one space between words; and do not append punctuation to words. Unlike in XB, **.**(period) +(positive) and **-**(negative) are pronounced.

Commas can be used for a short pause both in XB and compiled like this: CALL SAY(“HELLO , , THERE”. More than one comma can be used for a longer pause.

If a word is not found in the speech synthesizer's vocabulary, Extended BASIC will sound out the letters of the word. The compiler simply skips the word. If you want to say the letters “A B C” you should put spaces between the letters. CALL SAY(“A B C”) works the same in XB and compiled.

An undocumented feature of XB is the use of # to consider a phrase as one word. Neither TEXAS nor INSTRUMENTS is in the speech synthesizer's vocabulary, but TEXAS INSTRUMENTS is. It can be spoken with CALL SAY(“**#T**EXAS INSTRUMENTS”) This also works with CALL SPGET(“#TEXAS INSTRUMENTS”,A$).

Do not use any of the following as a name for a user subprogram:

The letters NC, NV, NA, SC, SV, SA, L followed by a number, or any of the names below:

```
ABS     CLLADR  CWRIT1  EA5WS   GPBUFF  INPUT3  NEXT    PRNTN8  SCPXS8  SIZLTH  STAR3   VREAD1
ACCEP1  CLOSE   CWRIT2  EAINT   GPLCHR  INPUT4  NEXT1   PRNTN9  SCPXSB  SLIST1  STAR4   VSB4
ACCEP2  CLOSE2  CWRIT3  EARLRT  GPLLNK  INPUT5  NEXT10  PUTSTK  SCPXU2  SLIST2  STAR5   VSBR
ACCEPT  CLRLN   CWRIT8  EARLYC  GPLWS   INPUT6  NEXT11  QMARK   SCPXU3  SLIST3  STAR6   VSBR1
ACCSCP  CLRLN1  CWRITE  ELSS    GR4     INPUT7  NEXT12  RAND1   SCPXU4  SLIST4  STAR7   VSBR2
ADD     CLRLN2  CYAN    ELSS1   GR4LB   INPUT8  NEXT13  RAND2   SCPXU5  SLIST5  STAR8   VSBW
AMATCH  CLRSC1  DATPNT  ENDCC   GR6     INPUT9  NEXT2   RAND3   SCPXUP  SLOFF   STAR9   VSBW2
AND     CLRSCN  DELAY   ENDIF   GSTAT   INPUTN  NEXTSP  RAND4   SCREE1  SLOFF1  STKPNT  VSBW96
ASC     CLT     DELAY1  EOF     GTAR1A  INT     NOCOI1  RAND5   SCREE2  SLOFF2  STOP    VSCR1A
ASTRN1  CLT1    DELAY2  EOF1    GTAR1B  INVID   NOCOIN  RANDBK  SCREEN  SLP2    STRN    VSCR1Z
ASTRN2  CMPAR1  DELS1A  EOF2    GTPABA  INVID1  NOPLAY  RDSCR1  SCRENE  SLP2A   STRPAD  VSCR2A
ASTRNG  CMPAR2  DELSP1  EOF3    GTSPNO  INVTX1  NOT     RDSCR2  SCRLA2  SNDOFF  STRS    VSCR2X
AT      CMPAR3  DELSP2  EORT    GXMLAD  INVTXS  NOWNDW  READ    SCRLAT  SOUND   STRST1  VSCR3A
AT1     CMPAR4  DELSPR  ERR     H0360   IRND    NULLST  READ2   SCRLBK  SOUND1  STRST2  VSCRL1
AT1A    CMPAR5  DERRLN  ERRLN   H10     JOYST   NXTPHR  READBK  SCRLDN  SOUND2  STRST3  VSCRL2
AT2     CMPAR6  DFWND1  ERROR   H2320   JSTADR  NXTSTR  READER  SCRLF1  SOUND3  STRST4  VSCRLB
AT3     CMPAR7  DFWNDW  ERROR1  H2C00   KEY     OLDCHR  READSP  SCRLF2  SOUND4  STRSTR  VSCRM1
AT4     CMPAR8  DIRECT  ERROR5  H4000   KEY1    OLDINT  RESTO1  SCRLF4  SOUND5  SUBEN1  VSCRM2
ATPNTR  CMPARE  DISP3B  ERRRPT  H8000   KEY2    ONE     RESTO2  SCRLFS  SOUND6  SUBEN2  VSCRM4
BACK    CNE     DISP3C  FAC     HCHAR   KEY3    ONGOS1  RESTOR  SCRLLF  SOUND7  SUBEN3  VSCRMU
BEEP    CNS     DISP3E  FILERR  HCHAR1  KEYBP   ONGOSU  RETUR1  SCRLP   SOUND8  SUBEND  VSCROL
BEEP1   CNS1    DISP3F  FOR     HCHAR2  KSC1    ONGOTO  RETURN  SCRLRT  SPACE1  SUBEXI  VSFLAG
BKINT   CNS1A   DISP4D  FORX1   HCHAR3  KSCAN   OPEN    RGSTRS  SCRLS1  SPACES  SWPPA1  VWA
BKPDSR  CNS2    DISP4E  FORX2   HCHAR4  LASTDT  OPEN1   RND     SCRLUP  SPCHRD  SWPPAD  VWRITE
BLWPWS  CNS3    DISPL1  FORX3   HCHARX  LASTLN  OPENBK  RPTER1  SCRN1   SPCHWT  SWPSC1  VWTR
CALL    CNS7    DISPL2  FORX4   HCHARY  LCDEFS  OPTBAS  RPTER2  SCRN1A  SPCOL   SWPSC3  VWTR1
CALL1   CNS8    DISPLA  FORX5   HCHGAD  LDCLR   OR      RPTERR  SCRN1B  SPDIS1  SWPSC4  WAIT
CALL2   CNS9    DISPLY  FREEZE  HEADER  LDCLR1  OUT     RPTS    SCRN2   SPDIS2  SWPSCR  WAIT1
CALLS1  CODE    DISTA1  FRSTDT  HEXDE2  LDGADD  PAB     RPTS1   SCRN2A  SPDIST  SYNC    WAIT2
CALLS2  CODEND  DISTAN  FRSTLN  HEXDE3  LDRGST  PABADR  RPTS2   SCRN2Z  SPDOVR  SYNC1   WFRSTR
CALLSB  COIALL  DIVID1  FRSTST  HEXDEC  LEN     PATTER  RPTS5   SCRNPT  SPEAK   SYNTH   WHIGHT
CEQ     COINC   DIVID2  GARBA1  HIGH    LEN1    PEEK    RTN     SCRNRT  SPEAK1  TAB     WINDO1
CEQ1    COLON   DIVID3  GARBA2  HILIT1  LET     PEEK1   RTNAD   SCROB   SPGET   TAB1    WINDO2
CGE     COLOR   DIVID4  GARBA3  HILITE  LET1    PI      RUN     SCROB4  SPGET1  TAB2    WINDO3
CGT     COLOR1  DIVID5  GARBA4  HX0010  LET2    PLAY    RUN1    SCROB5  SPGET2  THAW    WINDOW
CHAR    COLOR2  DIVID6  GARBA5  HX0018  LIMZRO  PLYR1   RUN10   SCROLL  SPGET3  TYPE    WKSP
CHAR2   COLORA  DIVIDE  GARBA6  HX001E  LINPTN  PLYR1A  RUN2Q   SCRUP1  SPGET5  VAL     WKSP1
CHAR2A  COLORC  DLINK1  GARBAG  HX0051  LINPUT  PLYR1B  RUNEA   SCRUP2  SPGFLG  VALID   WLASTR
CHAR2B  COLORD  DLINK2  GASIZ1  HX0300  LOAD    PLYR2   RUNEA5  SCRUP3  SPINI1  VCHAR   WLCOL
CHAR2C  COMDLY  DLINK3  GASIZ2  HX6080  LOAD1   POS     RUNV    SCRUP4  SPINI2  VCHAR1  WRCOL
CHAR2E  COMMA   DLY12   GASIZE  HX8000  LOADLP  POS0    SAY     SCRUP5  SPINI3  VLDRO1  WWIDTH
CHARP1  COMMA1  DLY42   GCHAR   HX8080  LOADSP  POS1    SAY1    SEARC1  SPINIT  VLDRO2  XB255A
CHARP2  COMMA2  DONE    GET0    HXFFF0  LOCATE  POS2    SAY1A   SEARCH  SPLOC   VLDRO3  XBEA5
CHARPA  COMMA5  DONEX   GET1    IF      LOW     POS3    SAY1T   SEGS    SPLOC1  VLDRO4  XBRTN
CHARPB  COMMA6  DR3LB   GET2    IF2     MAGNIF  POSITI  SAY2    SEGS1   SPPAT   VLDROU  XBRTN1
CHARSE  COMMA7  DRCTL2  GET3    IF3     MATCH   PRIN7B  SAY3T   SEGS2   SPPAT1  VLDSTR  XBRTN2
CHARTB  COMMA8  DRCTL3  GET4    IF4     MAX     PRIN9A  SAY4T   SEGS3   SPPAT2  VMBR    XBRTN3
CHPAT2  CON     DRCTL4  GETAR   INP13A  MAX0    PRINB3  SAY5T   SEMI    SPRIT1  VMBR1   XMLRTN
CHRS    CONCA1  DRCTL5  GETAR1  INPTN1  MAX2    PRINB4  SAY6T   SETADR  SPRIT2  VMBR1A  XOR
CHRSE1  CONCA2  DSKBUF  GETAR2  INPTN2  MAX3    PRINBK  SBTRCT  SETEQ   SPRIT3  VMBR1B  XPONE1
CHRSE3  CONCA3  DSRAD1  GETARR  INPTN5  MIN     PRINT   SC1CLR  SETSI1  SPRITE  VMBR2   XPONE2
CHRSED  CONCA4  DSRADD  GETSTK  INPTNL  MINUS   PRINT2  SC1DC   SETSI2  SPRMO   VMBR5   XPONE6
CHRSRT  CONCA5  DSREND  GLINK1  INPU10  MLTPLY  PRINT3  SC2CLR  SETSI4  SPRMO1  VMBW    XPONE8
CHSET2  CONCAT  DSRLNK  GLNKWS  INPU11  MONIT3  PRINT4  SC2DC   SETSI6  SQR     VMBW1   XPONE9
CHSET3  CRAWL   DSRWS   GODSR   INPU12  MONIT4  PRINT5  SCPXD2  SETSI7  SQR1    VMBW1A  XPONEN
CHSETD  CRSPOS  DWIND   GODSR1  INPU13  MONIT5  PRINT6  SCPXDN  SETSI8  SQR2    VMBW1B  XPONEX
CHSETL  CSN     DWNROW  GODSR2  INPU14  MONITG  PRINT7  SCPXL2  SETSI9  SQR5    VMBW2   XPONEY
CHSETZ  CSN1    EA5     GODSRE  INPU4A  MONITR  PRINT8  SCPXLF  SETSIZ  SQRERR  VMBW5   XPONEZ
CLE     CSN2    EA5B    GOSUB   INPU4B  MONWS   PRINT9  SCPXR2  SGN     STAR0   VMWLP1  XTAB27
CLEAR   CSN3    EA5B1   GOSUB1  INPU5A  MOTION  PRINTN  SCPXRT  SGN1    STAR1   VMWLP2  ZERO
CLEAR1  CSN4    EA5C    GOSUB2  INPUT   NAMLEN  PRN5A   SCPXS2  SGN2    STAR10  VRD
CLEAR2  CSN5    EA5D    GOTO    INPUT2  NBR     PRNTN1  SCPXS4  SIZE    STAR2   VREAD
```

In case of trouble...

Here are some steps that you can take to try to sort things out if there is a problem with the compiler.

Sometimes the compiler does not like one or more of the statements in the XB program. Normally it will display "L10" (or whatever the first line number is). If successful in compiling that line it will then display “L20” and so on until it is done. If it gets stuck on a line number then there is something in that line that it doesn't like. Check the XB program and try to see which statement is unsupported.

The compiler will report if it was able able to successfully compile your XB program. If so it will return to the menu where you can choose to assemble the code. The assembler might issue an error message during the assembly process. If so then the error is probably in the source code file the compiler just made, not in the runtime routines. The message will be something like this: `undefined symbol 0141.` This tells you that there is something wrong in line 141 of the compiled source code. Examine it to see if you have used an unsupported statement or if there is something that doesn't look right. This is another good reason to use Classic99, because the files are in windows format and can be opened and viewed with a text editor such as Notepad. Except for B @RUNEA5 there should be nothing but DATA statements, something like the following compiled code:

```
       DEF RUN,CON
RUNEA  B @RUNEA5
FRSTLN
L100
FOR1
       DATA FOR,NV1,NC1,NC2,ONE,0,0
       DATA COLOR,NV1,NC3,NC4
       DATA NEXT,FOR1+2
L110
       DATA DISPLY,NC1,NC5,SC1,NC6,NC7
L130
       DATA AT,NC8,NC9
       DATA SIZE,NC3
       DATA ACCEPT,SV1

LASTLN DATA STOP
- - - - (lines are omitted)- - - -
SC0
SC1    DATA SC1+2
       BYTE 9,98,97,99,107,103,114,111,117,110
       EVEN
SV0
SV1    DATA 0 Z$
- - - - (lines are omitted)- - - -
       COPY "DSK1.RUNTIME1"
       END
```

The code the compiler creates should be understandable when compared to the original XB program. Look for a missing DATA statement or something that doesn't look right. If the assembler gives a line number you should be able to find the error easily.

USING ASM994A WITH CLASSIC99 AND XBGDP

Be sure your computer is set up so it will show file extensions. If you do not know how to do this, do a search for “How to show file extensions in Windows 10/8/7”

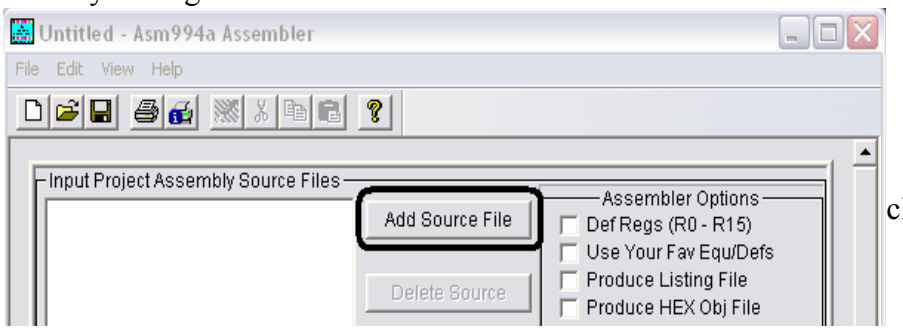
Set up the Game Developer's Package as described in *Using XBGDP*. DSK1 should be the folder called ISABELLA. The runtime routines and Asm994a.exe are already in this folder. Win994a is a nice emulator for the TI99 that comes with a huge amount of cartridge and disk software. If you want to try it out, the latest version can be found at www.99er.net on the home page. It is on the left under emulation.

Because Assm994a is a windows program it does not know anything about DSK1, DSK2, etc. The most foolproof way to use it is to have the source code created by the compiler, the runtime routines and Asm994a in the same folder. These are already in DSK1 (ISABELLA), so let's leave them there, at least for our preliminary testing. Open the ISABELLA folder, then right click on Asm994a.exe and create a shortcut. Drag and drop the shortcut to your desktop.

Let's test it by recompiling *HELLO*. The steps for compiling HELLO were described in *Using XBGDP*. Follow them up to the point in the compiler where you are asked:
`Using Asm994a?` Press Y and Enter, then Enter twice more to Proceed.
When the compiler is finished and returns to the main menu it knows you will be using Asm994a, so it bypasses the Assembler and points to Loader.

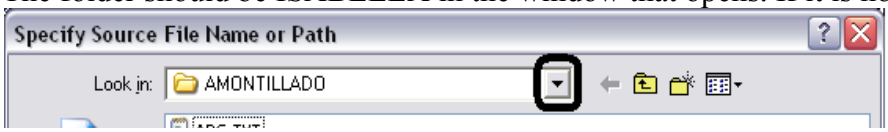
Now it's time to try out Assm994a. Windows 10 will look a little different from the XP screen shots shown here, but the steps are exactly the same.

Start by adding a Source File.



click here.

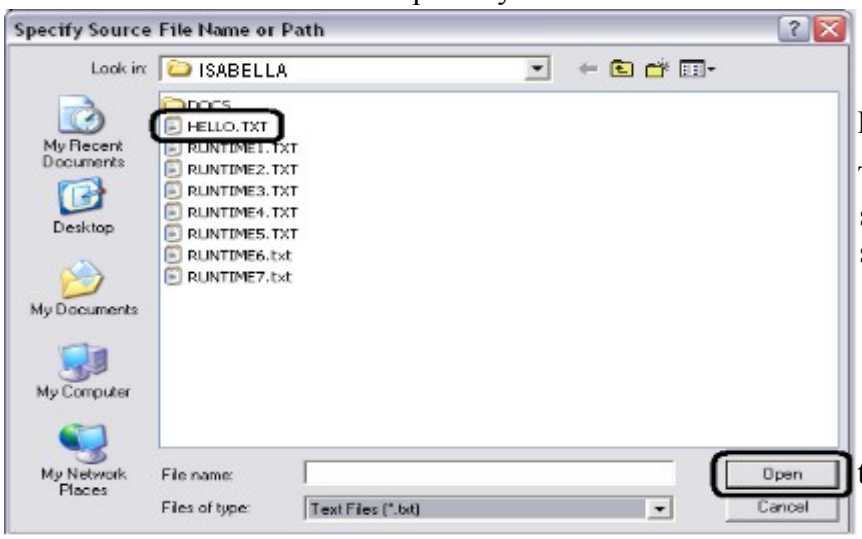
The folder should be ISABELLA in the window that opens. If it is not, then:



click here

and select the ISABELLA folder in the new menu. And click on Open.

When the ISABELLA folder is opened you will see a menu with all the text files in the folder.



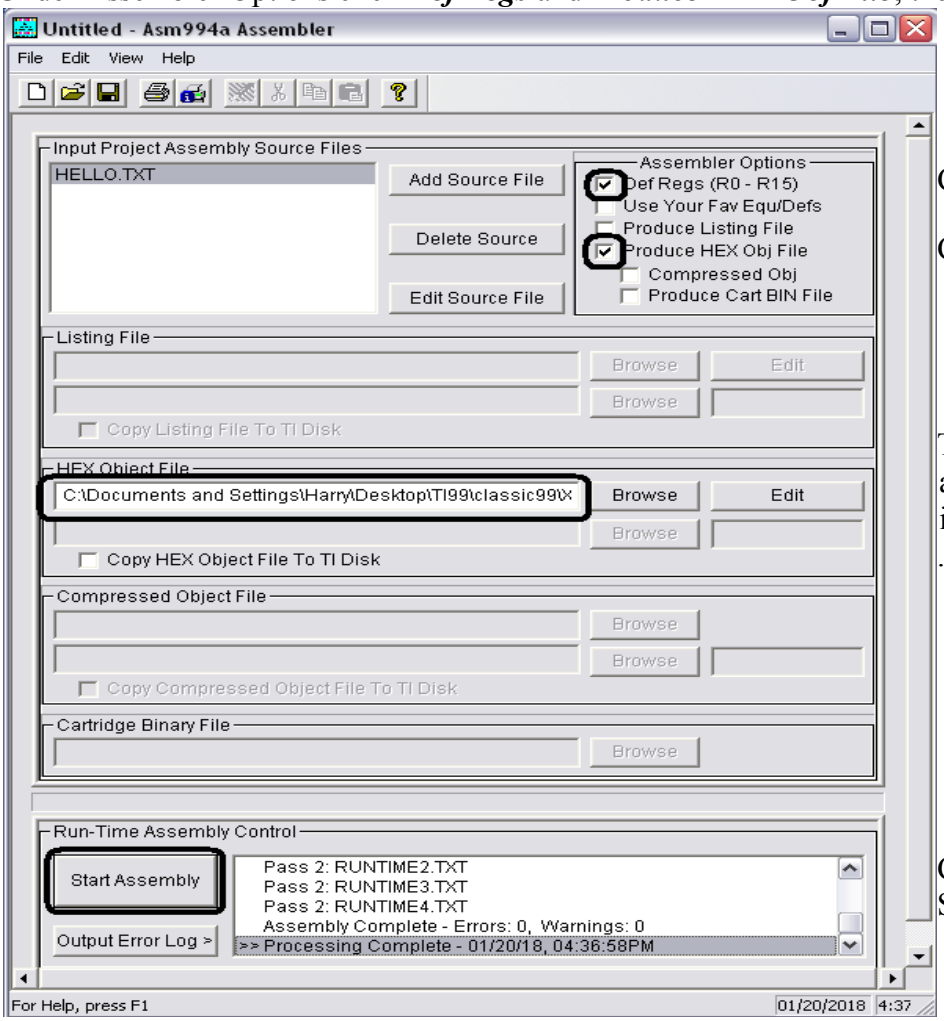
First click here.

The runtime files, compiled source files, and Asm994a should be on the same disk

then click here.

The menu closes when you choose a file name.

Under Assembler Options click ***Def Regs*** and ***Produce HEX Obj File***, then ***Start Assembly***.



Click here.

Click here.

The Object File is automatically filled in for you with the .obj extension

Click here to Start Assembly

If all goes well you see the message ***Assembly Complete – Errors: 0, Warnings: 0***

Click on the Classic99 window and you are back to familiar territory.
Press Enter for the LOADER then press Enter at the prompts:
DSK1.HELLO.OBJ
CALL LINK("EA5,"DSK1.HELLO-E")
SAVE DSK1.HELLO-X
RUN Set CPU speed to normal and press Enter.

You can see there is some set up to use Asm994a the first time, and you may wonder whether it's worth it when a just few keystrokes will have the TI Assembler up and running.

Let's find out. In developing a program, usually you'd be making a number of changes to the XB program and then recompiling. Let's try changing HELLO. Break the compiled program with Fctn4, Quit, press a key, press 2 for XB. The menu comes up pointing to EXTENDED BASIC. Press Enter, and press Enter again to load HELLO. Change the text in line 10.
10 A$=" Hello World! How are you doing???"
Type SAVE and follow the prompts to recompile. When the menu comes up pointing to LOADER don't forget that you need to assemble. Asm994a is already filled in for you and you just have to click ***Start Assembly.*** Then back to Classic99 to load, save and run the program.

See how much faster that is? Assembling the second time only took a few seconds.

As noted earlier, this is the easiest way to use Asm994a, but I do not particularly like the way DSK1 gets cluttered up when using this method. Once you are familiar with using Asm994a, I would suggest setting up a different disk for program development. I use DSK4 with the windows name *WorkingDisk,* but the disk number can be from 2 to 9 and the windows folder can be any name you want. You have to copy the runtime routines and Asm994a to DSK4. (WorkingDisk) This is where you will have the XB or XB256 source programs, as well as all the compiled files. Because it is in a new location, be sure to delete the old shortcut, then make a new shortcut to Asm994a and move it to your desktop.

USING RUNTIME ROUTINES FROM THE ORIGINAL COMPILER

If your program is written in TI BASIC you can now use the runtime routines that were part of the original TI BASIC compiler. The advantage is that the program created is considerably smaller, plus it may run a bit faster due to less overhead in the interrupt routine. The big disadvantage is that it only supports TI BASIC instructions (with a few additions from XB), and there have been no improvements for many years.

Most users will not want to use this, so it is turned off by default. To enable this option type:

OLD DSK1.COMPILER
uncomment line 230
SAVE DSK1.COMPILER

Now when the compiler runs you can press "Y" when prompted "Use TI BASIC runtime?" Default for this prompt is always "N".

The procedure for compiling a program is identical to the current version described above and in *Using XBGDP*. The limitations of this earlier compiler are described below, taken verbatim from the original manual. Do *not* put the runtime routines in low memory!

The BASIC compiler is able to compile many TI BASIC programs, although sometimes minor changes have to be made to the BASIC code. Some examples:
32767+1=32768 in BASIC
32767+1=-32768 in the compiled code
10 IF RND>.5 THEN 100 ELSE 200 won't work properly in the compiled code. Instead, use 10 IF INT(RND*2)=1 THEN 100 ELSE 200 which gives either a 0 or a 1 in both BASIC and the compiled code.
200*200=40000 in BASIC; -25536 in compiled code.
Remember that the compiler only works with integer numbers from -32768 to 32767. If an operation such as dividing or SQR can give a non integer result, then you should use INT in the BASIC program to be sure that the BASIC and compiled programs function the same.

The timing of delays loops has to be modified. FOR I=1 TO 500::NEXT I gives a delay of several seconds in XB or BASIC; a fraction of a second in the compiled code. The best way to do a delay is to use CALL SOUND. For a 2 second delay you would use CALL SOUND(2000,110,30)::CALL SOUND(1,110,30). Neither BASIC nor the compiler can process the second call sound until the first has finished, so you get the full 2 second delay. This method makes it possible to create delays that work the same in BASIC or compiled code.

Following is a list of the TI BASIC operations supported by the compiler:

As in XB, simple multiple statement lines can be used, separating the statements with the double colon

CALL LINK("RUN") - same as RUN in XB Cannot use RUN or RUN line # within a program.

CALL LINK("CON") - same as CON in XB
<FCTN 4> breaks the program as in XB except during INPUT.
All relational operators work the same as in BX. These include < > = <> <= >=

Arithmetic operators all work as they do in BX. Exponentiation (|) not supported. Remember that dividing 5/2 will give 2, not 2.5. You can use INT in the BASIC program when dividing (for example INT(5/2) to be certain that BASIC and the compiler give the same results.

Logical operators from XB have been included: NOT; AND; XOR; OR

LET - optional
REM - All remarks will be removed from the compiled program, but you can GOTO a
REM statement just like in BX. Use of REM will not increase the size of the compiled program.
! - the exclamation point REM from XB has been included.
END
STOP
GOTO
ON-GOTO
IF-THEN-ELSE - XB style of IF-THEN-ELSE *is now* supported, with the same minor restrictions found in the XB compiler.
FOR-TO-STEP - step optional; +1 assumed
NEXT

INPUT - Can use the optional prompt, but can input only 1 string or number per INPUT statement.
READ
DATA (Do not GOTO a DATA statement!)
RESTORE
PRINT - works like TI BASIC, including TAB and the print separators ;,:
DISPLAY - equivalent of PRINT.

CALL CLEAR
CALL COLOR - expanded to work like XB except for color of sprites.
CALL SCREEN
CALL CHAR - expanded to work like XB.
CALL HCHAR
CALL VCHAR
CALL SOUND - cannot handle frequencies greater than 32767. (Neither can my ears!)
CALL GCHAR
CALL KEY
CALL JOYST

ABS
INT
RANDOMIZE - can be used, but has no effect; it is done automatically
RND - returns a value of 0. RND is only useful when it is multiplied by another number. i.e. INT(RND*6) gives the same results (0,1,2,3,4,5) when compiled as it does in BX.

SGN
SQR - gives same number as INT(SQR(N)) in BX
ASC
CHR$
LEN
POS
SEG$
STR$
VAL

String concatenation (i.e. A$&&B$) works the same as in XB. String truncated if over 255 characters; no warning given.

DIM is optional but using it can reduce size of the compiled program.
OPTION BASE
ARRAY LIMITATION - Important!! The program being compiled cannot use nested arrays. For example, if you have the two arrays DIM A(10),DIM B(10); you can use Q=A(X+Y-Z) but you can't nest the arrays like this: Q=A(B(7)). Use of nested arrays will cause the compiled program to crash!!! For the above example you would have to split up the statement something like this: X=B(7)::Q=A(X)

GOSUB
RETURN
ON-GOSUB

NOT SUPPORTED:

DEF
ATN
COS
EXP
LOG
SIN
TAN

No File processing capabilities have been implemented at this time.

The following have no meaning in a compiled program:
LIST
NUM
RES
BREAK
UNBREAK
CON - use CALL LINK("CON")
TRACE
UNTRACE
EDIT