Divelbiss Boss Bear
User's Manual

Divelbiss Corporation

Release 2.05 for software version 2.11

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WARNING

The Boss Bear and UCP, as with other solid state controllers, must not be used alone in applications which would be hazardous to personnel in the event of failure of this device. Precautions must be taken by the user to provide mechanical and/or electrical safeguards external to this device. This device is NOT approved for domestic or human medical use.

All program examples are for the Boss Bear. If using the UCP, minor changes in software will be needed because of hardware differences.

Contents

Chapter 1
Introduction

The Divelbiss Boss Bear is a unique programmable control system that integrates many control functions into one easily used package. It starts as a compact, highly integrated industrial computer system that is programmed using an extended, compiled BASIC. It becomes an operations panel, containing a 2 line by 40 character display and a 20 key entry pad; both are fully programmable to suit the user's requirements. It supports onboard control hardware such as a high speed counter, analog inputs, a Real Time Clock, two serial ports, nonvolatile memory, and EPROM storage of the user's programs. Three expansion ports are available for adding optional modules, including analog outputs, analog inputs, high speed counters, resolver inputs, high speed input/output, etc.

The Boss Bear can be interfaced to a Divelbiss Bear Bones programmable controller with a single cable, allowing a true multi-processing system to be easily created; this forms an inexpensive system that provides performance equal to much larger controllers.

Several Boss Bears can be linked together with a network to provide control over a larger area or to return information to a central point. This network can then be linked to another computer system, which can provide long term data storage and display, supervisory control of the entire network, and perform Statistical Process Control.

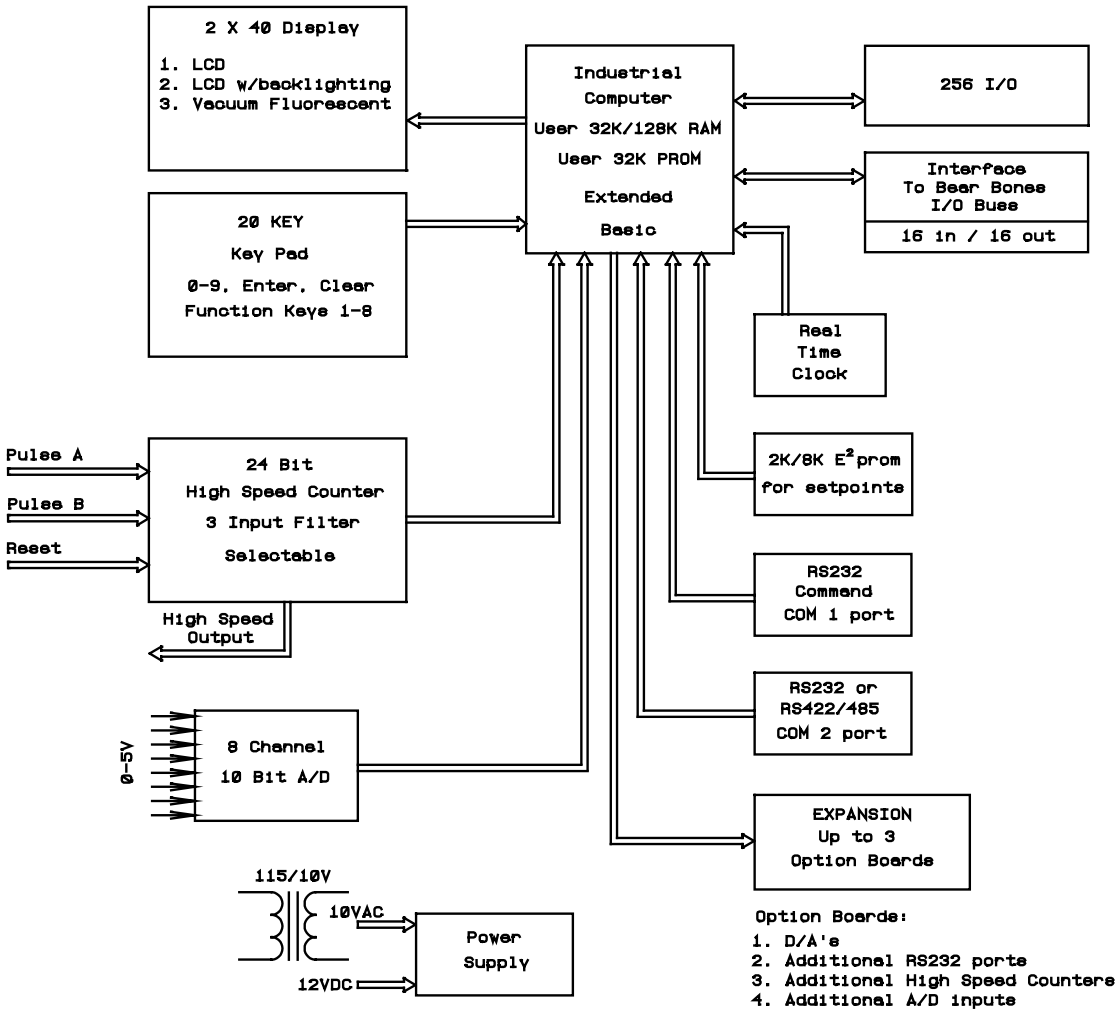


Figure 1 – Boss Bear system block diagram

1.1 Description of Features

A Boss Bear system consists of the Boss Bear, options added onboard the Boss Bear itself, option modules plugged into the Boss Bear, and I/O expander modules connected to the Boss Bear. By choosing the options carefully, an inexpensive system can be built with only the hardware necessary to complete the task.

The minimal configuration of the Boss Bear contains the microprocessor circuitry with the Bear BASIC compiler in PROM, 128K of RAM, an RS-232 serial port, EPROM programming capability, and the Bear Bones interface. The RAM is used to hold the user's program source code while it is being written, and to hold variables and data while the user's program is executing. The serial port is used to interface with a terminal or personal computer to allow entry and editing of programs. The onboard EPROM programmer allows the user's program to be saved and loaded, either as source code or as executable object code. The Bear Bones interface connects the Boss Bear to a Divelbiss Bear Bones programmable controller to form a powerful multi-processing control system.

The Boss Bear may be purchased with a variety of options installed in the unit, such as a front panel display and keypad, a high speed counter, analog input circuitry, a real time clock, a second serial port, and nonvolatile memory.

The front panel display is a 2 line by 40 character display; this may be a liquid crystal display (LCD), a backlit liquid crystal display, or a vacuum fluorescent display (VFD). The keypad is a 4 row by 5 column tactile feel membrane keypad. These are both fully programmable by the user.

The high speed counter is a 24 bit up/down counter with a built-in comparitor, providing a high speed output when a specified count value is reached. This counter may be programmed to support position control, rate metering, tachometer batch control, etc. It can support multiple setpoints under software control.

The analog input circuitry contains an 8 channel, 10 bit, with 12 bit optional analog to digital convertor (A/D). The values returned by the A/D can be displayed using the required engineering units, used in a multiple setpoint control algorithm, and used as part of a PID control loop, for example.

The Real Time Clock (RTC) maintains the current time and returns it as year, month, day, hour, minute, second, day of week, and day of month. It is battery backed up, and so will keep the correct time even when the Boss Bear is not powered.

The second serial port supports RS-232, RS-422, and RS-485. RS-232 is used to communicate over short distances. RS-422 is used over longer distances and in electrically noisy environments. RS-485 is used when several units need to communicate over two wires, as in a network. The two onboard serial ports support 150, 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 baud.

1.2 Organization of This Manual

This manual is divided into 8 chapters, 5 appendices providing supplemental information, and an index:

Chapter 1, "Introduction", provides an overview of the Boss Bear and a description of this manual.

Chapter 2, "Getting Started With the Boss Bear", describes how to set up the unit, attach it to a terminal, enter Bear BASIC programs, use the editor, and execute programs.

Chapter 3, "Overview of the Bear BASIC Compiler", describes the various elements of Bear Basic and how they fit together.

Chapter 4, "Writing Control Applications in BASIC", is an elementary tutorial on programming for real time control systems, with emphasis on using the features of Bear BASIC.

Chapter 5, "Multitasking in Bear BASIC", explains the specifics of using the multitasking features of Bear BASIC.

Chapter 6, "User Interface Support", describes how to use the onboard display and keypad, and also discusses using a serial communications port with a terminal.

Chapter 7, "Onboard Hardware Support", describes the BASIC instructions that support the hardware options available on the Boss Bear.

Chapter 8, "Bear BASIC Language Reference", is an alphabetical list of all direct commands, statements, operators, and functions in Bear BASIC.

Chapter 9, "Optional Modules", describes the optional hardware modules that are available for the Boss Bear.

Chapter 10, “Networking with the Boss Bear”, describes how to setup and use the Boss Bear network.

Chapter 11, “Error Handling in Bear Basic”, deals with the onboard Basic compiler.

Appendix A, "Specifications", list of system hardware and software specifications.

Appendix B, "Error Messages", describes the Boss Bear error messages.

Appendix C, "Accessing the Hardware", is a technical description of the hardware available onboard the Boss Bear.

Appendix D, "Using Assembly Language Subroutines", describes how to link assembly language routines into a BASIC program.

Appendix E, "Hardware Installation Recommendations", provides guidelines for installing the Boss Bear into the user's system.

Appendix F, “ASCII Character Table”, is the character table used in the Boss Bear.

Appendix G, “Bear Basic Release History”, is the version release history showing additions, modifications and anomalies in the Boss Bear Basic.

Appendix H, “UCP Onboard Hardware Support”, is the description of the UCP hardware differences from the Boss Bear.

Appendix I, “Using Fuzzy Logic”, is a brief description of fuzzy logic and how it is implemented on the Boss Bear and UCP.

1.3 Notational Conventions

In this manual, the following conventions are used to distinguish elements of text:

BOLD	Denotes hardware labelling, commands, and literal portions of syntax that must appear exactly as shown.
italic	Used for variables and placeholders that represent the type of text to be entered by the user.
EXAMPLE	Used for example programs, sample command lines, and text displayed by the Boss Bear.
SMALL CAPS	Used to show key sequences, such as CTRL-C, where the user holds down the <Ctrl> key and presses the <C> key at the same time.
[ ]	Brackets are used to indicate optional elements of a command, such as **LOAD** [*program_num*] where *program_num* is optional.

Chapter 2
Getting Started With the Boss Bear

The Boss Bear is a relatively simple computer system to get up and running; normally, even an inexperienced user can have the unit operating a short while after unpacking it. This chapter describes how to set up the Boss Bear and use its basic features. The chapter includes sample programs that may be entered to learn about the general functions of the system; these programs may then be used as a starting point from which to develop applications.

2.1 Connecting to a Terminal or Personal Computer

The Boss Bear requires a 10 volt AC or 12 volt DC power source in order to operate; see appendix A to determine the current drain for the various Boss Bear configurations. A transformer is available from Divelbiss that allows the unit to be powered from the 120 volt AC power line. The unit has onboard rectification and regulation to generate the voltages used inside the system. 10-12 volts is fed into the system using the 3 pin **POWER INPUT** connector on the back of the unit; see Figure 2. It is extremely important to provide an earth ground for the unit, both as a safety precaution and to minimize electrical noise related problems; earth ground is the third prong on a standard 3 prong electrical wall socket. **WARNING: DO NOT USE AUTO TRANSFORMER.**

In order to program the Boss Bear, it must be attached to a terminal or a personal computer that is running a serial communications program. This manual assumes that a personal computer is being used; the operation of the unit is the same in either case. A cable connects the Boss Bear to the personal computer; Divelbiss can supply a cable that will allow the unit to be used with an IBM

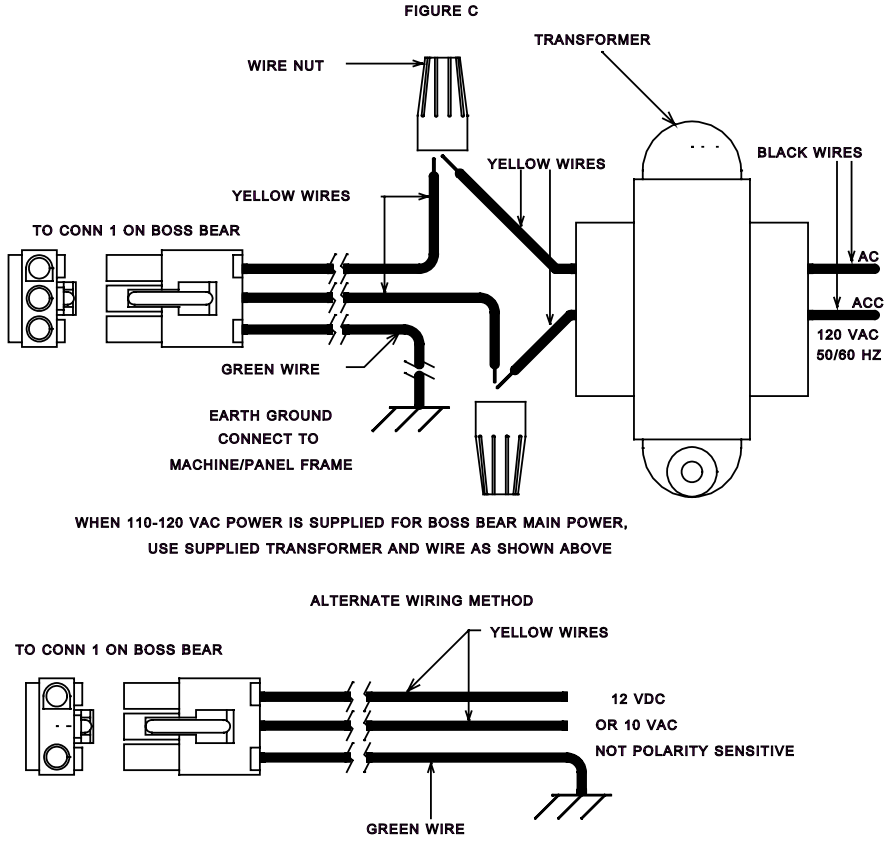


Figure 2 - Boss Bear Power Supply Wiring Schematic

PC or compatible, or a null modem cable can be used. The user can easily manufacture a cable to match other systems, see Figure 3. Note that pins 7 and 8 (the RTS and CTS lines) must be connected to valid signals from the terminal/computer, or they must be connected to each other.

Once the cable is installed between the Boss Bear COM1 connector and the personal computer, apply power to the personal computer and enter the communications program. The serial communications parameters must be set to 9600 baud, 8 data bits, no parity, 1 stop bit, and XON/XOFF flow control enabled; these values are required in order to match the default values used by the Boss Bear. Make sure that the communications program is set to use the serial port that is connected to the Boss Bear. Apply power to the Boss Bear; it should respond with a signon message followed by the BASIC compiler prompt:

```
BEAR BASIC Compiler Version 2.01
>
```

No sign on message for Versions 2.03 and higher with battery backup memory. Only the ">" sign.

Each time that the ENTER key is pressed, the prompt character will be printed on the next line down. The communications program should be set to emulate an ADM-3A or ADM-5 terminal type, in order for the cursor positioning commands on the Boss Bear to work correctly.

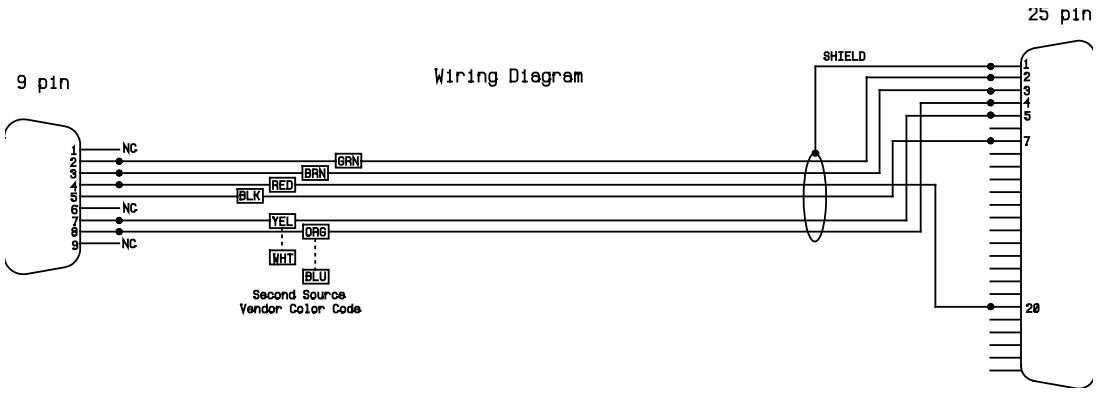


Figure 3 – Serial Port COM 1 Wiring Diagram

2.2 Writing a Program in Bear BASIC

The best way to become familiar with the Boss Bear is by writing some simple programs; the following sections will use several programs to demonstrate different features. We will start with a very simple program. The first program that is always run on a new computer system looks like this:

```
100 PRINT "HELLO, WORLD!"
```

Before entering this program, type **NEW** followed by the ENTER key; this will clear out any existing program that might be in the Boss Bear memory. Although the examples in this manual primarily use upper case characters, the Boss Bear is not case-sensitive, and so lower case and upper case may be used interchangeably. Also, from here on it is assumed that the user presses ENTER at the end of each line.

Enter the one line of the program in and then enter **RUN**. The Boss Bear will print the message COMPILED followed by HELLO, WORLD!. It will then return with the prompt, awaiting further commands. The screen should look like this:

```
> NEW
> 100 PRINT "HELLO, WORLD!"
> RUN
COMPILED
HELLO, WORLD!
>
```

If an error message is printed instead of COMPILED, after typing **RUN**, then line 100 was probably entered incorrectly; try entering it again, being careful to type it exactly as shown. Remember to put the double quote marks around the HELLO, WORLD! message.

To modify a line of BASIC, just enter in a new line using the same line number; the new line will overwrite the existing line. To remove a line of BASIC, enter the line number with nothing after it; the line will be removed from the BASIC program. To look at your BASIC program, enter **LIST**; the program will be displayed on the screen.

2.3 Bear BASIC Command Line Operation

Bear BASIC has three different modes of operation: command line entry, compilation of the BASIC program, and execution of the BASIC program. The programmer interacts with Bear BASIC while in the command line mode; this is where programs are entered, edited, loaded, and saved. The user types a command after the compiler prompt (the '>' character), then Bear BASIC performs the command and returns with the compiler prompt again. The BACKSPACE key may be used to back up while entering a command.

When a line is entered while in the command line mode, it is first examined to see if it is a valid direct command; if it is, then the command is performed. If it isn't a direct command, then it is handled as a line of BASIC source code; if it isn't a line of BASIC source code, then an error is displayed. If it is valid BASIC source code, then it is entered into the current program.

2.4 Using the Command Line Editor

If it is necessary to change a line of the current BASIC program, the line can be retyped; the new line will replace the existing line. This is fine for short lines, but for longer lines this can cause a lot of extra typing. In order to minimize the effort required to modify a line of the program, Bear BASIC includes a line editor as a direct command. The EDIT command allows a single line of BASIC source code to be modified without retyping the entire line. For EDIT to work properly, the line must be less than 80 characters long; it must fit on a single line of the terminal. For the cursor positioning to work correctly in EDIT, the console terminal type must be set to ADM-3A or ADM-5.

To use EDIT, type **EDIT** followed by the line number of the BASIC line to be modified; for example, EDIT 120. The existing line will be displayed with the cursor at the first character in the line number. The cursor may be moved left and right with the following key combinations:

CTRL-S move the cursor left one character
CTRL-D move the cursor right one character
CTRL-A move the cursor to the beginning of the line
CTRL-F move the cursor to the end of the line

The editor can be toggled between insert and overwrite mode. In overwrite mode, any character typed will replace the existing character at the current cursor position. In insert mode, any character typed will be added at the current cursor position, causing the rest of the line to be moved right one character position. When the editor is invoked, it starts out in overwrite mode.

CTRL-V toggles between overwrite and insert mode

To delete characters from the line, either BACKSPACE or CTRL-G can be used. The BACKSPACE key deletes the character to the left of the current cursor position, causing the rest of the line to be moved left one character position. CTRL-G, on the other hand, deletes the character at the current cursor position, causing the rest of the line to the right to be moved left one character position.

CTRL-G deletes characters from line

When the desired changes have been made to the line, press ENTER to add the modified line back into the program; the modified line will replace the existing line. Pressing ESCAPE or any control key not listed above will abort the changes, leaving the existing line unchanged. After leaving the editor, the compiler prompt will be displayed again.

2.5 Loading and Saving Programs With a Personal Computer

If the Boss Bear is being used with a personal computer as the console terminal, then it may be desirable to transfer the current BASIC program to and from the computer's disk.

This allows the program to be edited on the personal computer, and to be printed out. The exact method of transferring files depends upon the communications program that is being used on the computer; it may be necessary to refer to the manual for that program to ensure proper file transfer.

To transfer a program from the personal computer to the Boss Bear, enter **NEW** to clear the current program out of memory, then enter **DOWNLOAD**. Execute the command in the communications program to send a text (or ASCII) file, and type in the appropriate file name. The file will be transferred to the Boss Bear. The file should not be echoed to the screen; if it is being echoed, then it may indicate that a CTRL-Z is stored in the file. If any syntax errors are encountered while sending the file, they will be displayed on the screen. After the file has been transferred, the Boss Bear will probably respond with the compiler prompt; if it doesn't, then type CTRL-Z, which turns off the DOWNLOAD mode. If two or more lines were entered using the same line number, then the warning message Warning: duplicate line numbers detected will be printed; this probably indicates an error in the BASIC source code.

To transfer a program from the Boss Bear to the personal computer, type **LIST** but do not press ENTER. Execute the command in the communications program to receive a text (or ASCII) file, and type in an appropriate file name. After the program is ready to receive the file, press ENTER to make the Boss Bear display the program; the program will capture it and store it in the selected file on the personal computer. After the entire BASIC program has been displayed, execute the command in the communications program to finish the reception of the file.

2.6 Loading and Saving Programs With an EPROM

The Boss Bear includes an onboard EPROM programmer that is used to save the user's programs. An EPROM is a device that can be written to electrically, but can only be erased by exposing it to ultraviolet light; EPROM stands for Erasable Programmable Read Only Memory. When an EPROM is erased, the entire contents of the EPROM are lost; there is no way to only erase part of the EPROM. The same file can be stored multiple times, allowing different versions to be saved while developing a program.

The programmer supports two sizes of EPROM: 32KB and 128 KB. KB stands for KiloByte, which is 1024 bytes. The jumper **JW3** (see **Figure 6**, page 7-2) must be set to match the type of EPROM that is being used; failure to set the EPROM type correctly could destroy the EPROM, along with its contents. The EPROM is mounted in a special carrier for easier handling; the carrier ensures that the EPROM can't be installed backwards. The switch **SW1** must be set to **PROG** (program mode) before the EPROM can be written to.

After installing the EPROM and checking that the **JW3** setting matches the EPROM type, the EPROM is ready to use. The DIR command will display the contents of the EPROM and the amount of unused space remaining. Two types of files can be stored on the EPROM: source code and compiled code. The source code is the human readable BASIC program; this should be stored so that it isn't lost. Compiled code is the executable code generated by the Bear BASIC compiler; this is stored on an EPROM so that it can be

automatically executed on power up, or so that it can be CHAINed to from another program. Each type of file is numbered sequentially on the EPROM, starting at 1.

After a BASIC program (the source code) has been typed in, it should be saved before compiling it and attempting to execute it; this is so that the program won't be lost if the Boss Bear crashes when the program is run. When entering a long program, it is also advisable to save the program periodically so that the entire program isn't lost in the event of a power failure. To save the source code to EPROM, type **SAVE** *progname*, where *progname* is the name of the program. The program name will be stored as the file name on the EPROM; if *progname* isn't entered, then it will default to all spaces.

After a program has been successfully compiled (ie. no syntax errors were encountered by the compiler), then the compiled code can be saved to the EPROM, by typing **SAVE CODE** *progname*, where *progname* is the name of the program. The program name will be stored as the file name on the EPROM; if *progname* isn't entered, then it will default to all spaces.

2.7 Automatically Executing a Program on Power Up

When the user's program is operational and the Boss Bear is to be installed, it will probably be necessary for the Boss Bear to automatically execute the program when it is turned on. If **SW1** is set to **RUN** (run mode), then the Boss Bear will load the last compiled code file from the EPROM and execute it. Since the Boss Bear executes the last compiled code file from the EPROM, the latest revision of a program will always be executed. If **SW1** is set to **PROG** (program mode), then the Boss Bear will respond with the compiler prompt when it is turned on. Preprogrammed Eprom cannot be used with newer versions of firmware without downloading and recompiling (erase Eprom and reprogram).

Chapter 3
Overview of the Bear BASIC Compiler

The Boss Bear software consists of two parts: the command line interface and the Bear BASIC compiler. The command line interface executes direct commands as they are typed in; it enters the BASIC source code, loads and saves programs, executes programs, and starts the compiler. Section 3.1 describes the direct commands that are available. The compiler converts BASIC source code into executable compiled code; it's input is the current BASIC program in memory. Sections 3.2 through 3.9 describe the BASIC compiler, the syntax of Bear BASIC, and the statements and functions that Bear BASIC supports. The Bear BASIC commands, statements, and functions are described individually in chapter 8.

3.1 Direct Commands

Direct commands are used while programming the Boss Bear, and entered at the compiler prompt. They can be grouped into three categories: file commands, compiler commands, and miscellaneous commands.

3.1.1 File Commands

DIR	display a listing of files on the EPROM
DOWNLOAD	disable echo while loading a program
LOAD [filenum] or	load a program from the EPROM
EPROM LOAD [filenum]	load a program from the EPROM
SAVE [CODE] [fname] or	save source or compiled code to the EPROM
EPROM SAVE [CODE] [fname]	save source or compiled code to the EPROM

3.1.2 Compiler Commands

C	abbreviation for COMPILE
COMPILE or C	compile the BASIC program
ERROR	enable error checking in compiled BASIC
G	abbreviation for GO
GO or G	start the compiled program executing
NOERR	disable error checking in compiled BASIC
R	abbreviation for RUN
RUN or R	compile and execute the current BASIC program
STAT	display memory usage and compiler version

3.1.3 Miscellaneous Commands

BYE	reset the Boss Bear
CLEARMEMORY	write 0's into all memory locations
CLS	erase the console display
E linenum	abbreviation for EDIT
EDIT linenum or E	enter the line editor to alter linenum
HELP	display help text
L	list the entire program
LIST [linenum] [,linenum]	list all or part of the program

LFDELAY	delay at the end of each line displayed
NEW	clear out the current BASIC program
SETOPTION DAC	set DAC initialization values

3.2 Organization of a Bear BASIC Program

The Bear BASIC language has a structured syntax that requires that particular elements of a program be placed in a specific order. Failure to follow this syntax could result in syntax errors, or, worse yet, an inoperable program.

3.2.1 Program Lines

A Bear BASIC program consists of a series of program lines, sometimes referred to as lines of code, or source lines. Each program line has a line number followed by one or more statements. The line number is an integer between 1 and 32767. If there is more than one statement in a program line, then each statement is separated by a colon (':'). The following are valid Bear BASIC program lines:

```
100 X=4

35 print "Hi there"

32000 J=K*4 + 3: IF J>0 Then GOSUB 2000:j=0
```

The following are invalid program lines:

`43000 PRINT X`	Line number is too large
`100 X=4 J=X`	No colon between statements

Bear BASIC does not require line numbers; if a line is entered without a line number, it will add 2 to the previous line number and assign that number to the new line. If used carefully, this can make the BASIC source code much more readable when it is viewed on a personal computer. BASIC stores lines in a tokenized format, where special codes are stored instead of the actual statement, in order to save space. A side effect of this is that the program will look different when it is LISTed than when it was entered. An example will demonstrate this; if the following is typed:

```
100   integer j,sum
      sum=0                          ' Initialize the sum
      for j=1 to 100
        sum=sum+j                    ' Add up the numbers
130   next j
      print "The sum is "; sum       ' Display the result
```

when this program is LISTed, the following is displayed:

```
100  INTEGER J,SUM
102  SUM=0: ' Initialize the sum
104  FOR J=1 TO 100
106  SUM=SUM + J: ' Add up the numbers
130  NEXT J
132  PRINT "The sum is ";SUM: ' Display the result
```

Notice that line numbers were added to the lines that didn't have them. Also, the only lowercase letters that remain are in text strings and comments. Bear BASIC is not case sensitive, so code can be entered in upper or lower case, but it is always stored in upper case.

3.2.2 Variable Declarations

Unlike many BASIC systems, all Bear BASIC variables must be explicitly declared. All variable declarations (ie. INTEGER, REAL, and STRING statements) must be at the beginning of the program. In order to create efficient code, the compiler needs to know how many variables there are before it generates any machine code. Bear BASIC is limited to 128 variable names in a program. No distinction is drawn between variables by mode. This means that the variable A2 is the same variable as A2$. If the variable is declared as both integer and string (both INTEGER A2 and STRING A2$ statements exist), a compilation error will result. Similarly, variable A is the same as dimensioned variable A(n). Bear BASIC supports a maximum of two dimensions for real and integer arrays; it supports single dimension string arrays.

3.2.3 DATA and READ Statements

All DATA statements must be located before the first READ statement in the program. DATA statements can be interspersed with other executable statements, but no DATA statement can follow a READ statement.

3.2.4 Placement of Tasks

In a multitasking program, the beginning of each task is identified with a TASK statement. The TASK statements must be in ascending numerical order starting with TASK 1. When a task is run, it begins execution with the statement following the TASK statement. The code located before the TASK 1 statement actually belongs to task 0; task 0 is present in every Bear BASIC program. The placement of tasks and subroutines can be critical. In general, the safest method is to not call subroutines that are located in another task. See Chapter 5 for further discussion of multitasking.

3.3 Numeric Constants

Constants are formed by combining decimal digits with an optional decimal point. Whenever a decimal point is included in a constant, the compiler assumes this constant is a real number. If the constant is expressed without a decimal point, the compiler assumes that the value is an integer. This has significance when combining real and integer values within an expression. Even though

Bear Basic is smart enough to convert constants between integer and real as required, programs will run more efficiently if modes are not mixed. Bear Basic provides a facility for using hexadecimal constants. Hexadecimal constants are specified with a leading dollar sign. $1AB represents the hexadecimal constant 1AB.

3.4 Variables

Bear BASIC variables are formed by a letter followed by up to six letters or digits. For example, A is a legal variable, as well as A0, A1, HI92, and JUMP. However, 9AB is not a legal variable, nor is A1234567899. String variables are formed the same way, but are followed by a dollar sign. HIYA$, A1$, A9$ are all legal string variables. A maximum of 128 different variables may exist in any given program. These variables may be in any form within the rules given above. Note that integer or real variables may not have the same name as string variables. For example, the variable A may not be used in the same program that uses the variable A$. Bear BASIC will try to use A and A$ as the same variable, and a string variable error will result. Similarly, a dimensioned variable must not have the same name as an undimensioned variable (for example, you cannot use B and B(n) in the same program).

All variables must be declared at the beginning of the program before any executable code is encountered. In practice, this means that the variable declaration statements (INTEGER, REAL, and STRING) should be the first statements in the program. If undeclared variables are found during the compilation, the compiler will display an error message. For strings, the string length is specified in the STRING statement (for example, B$(80)). If no string length is specified, a string length of 20 will be assigned. The maximum allowable string length is 127.
String arrays are defined by specifying the length of each element, followed by the number of elements in the array. STRING A$(10,20) specifies 20 strings, each of length 10. Any element can be accessed just like a singly dimensioned array. A$(3)="123" assigns a value to the third element of the string array.

Subscripted variables are specified within the INTEGER and REAL statements. Note that subscripted variables start with the zero dimension, and extend to the maximum dimension specified. Therefore, the statement INTEGER A(10) defines a variable with eleven members, A(0) through A(10).

Integer variables are stored using a sixteen bit two's complement representation. An integer value can range from +32,767 to -32,768. Positive values which exceed 32,767 will appear as negative numbers. Real values are four byte (32 bit) IEEE compatible single precision real numbers. This means that approximately 6.5 digits of precision are maintained for real numbers (ie. numbers between $\pm 3.4028235 \times 10^{38}$). Many BASIC interpreters and compilers use BCD mathematics or 64 bit representations resulting in high accuracy numbers that require lots of memory. Bear BASIC does not support either of these in the interest of maximizing speed. The user must be aware that a real number may not be exactly the number anticipated. For example, since real numbers are constructed by using powers of 2, the value 0.1 cannot be exactly represented. It can be represented very closely (within 2^{-23}), but it will not be exact. Therefore, it is very dangerous to perform

a direct equality operation on a real number. The statement `IF A=0.123` (assuming A is real) will only pass the test if the two values are exactly equal, a case which rarely occurs. This is true for all real relational operators, including, for example, the statement `IF A>B`, if values very close to the condition being measured are being used. Be aware that the number you expect may not be exactly represented by the compiler. If necessary, use a slight tolerance around variables with relational operators.

3.5 Operators

Operators are connectors within expressions that perform logical or mathematical computations.

These operators work both with integer and real numbers:

+	addition
-	subtraction
*	multiplication
/	division

Some operators are relational. They generate a nonzero result if their condition is met; the nonzero value is unspecified (ie. it isn't necessarily 1 or -1, as in many languages). These operators may be used in mathematical expressions, but they are more frequently used with IF/THEN statements:

>	greater than
<	less than
<> or ><	not equal to
=	relational equality test
>=	greater than or equal (integers and reals)
<=	less than or equal (integers and reals)
AND	logical AND
OR	logical OR

Note that AND and OR are evaluated in integer mode. Real arguments are converted to integer before AND and OR are evaluated. The equals sign ('=') is used in two different ways in Bear BASIC: as the equality operator, and as the assignment statement.

All operators are in a hierarchy that defines what operators will be evaluated first. The following is a list, from highest to lowest priority:

*, /
+,-
unary -, >, <, <>, ><
AND, OR

A variable may hold the result of a relational comparison. For example, A=R>0. Strings don't support the >= and <= relational operators. Some BASICs use + for string concatenation, but Bear BASIC programs must use the CONCAT$ function.

3.6 Expressions

An expression is a mathematical, logical, or string calculation, such as 2+3, A/B, A=4, or N$>C$. Expressions are formed using constants, variables, operators, and functions. Expressions may be combined to form complex expressions, such as (A+B)/SIN(A*SQR(C)); parenthesis are used to control the order of evaluation in a complex expression. The evaluation of an expression produces a numeric or string result that is used as an argument for a statement, or as part of another expression. An expression cannot stand alone; it must be an argument to a statement, function, or another expression.

The following examples demonstrate the features of expressions; the result of each expression is given to the right of the expression. In the examples, these variable values are used:

```
INTEGER J,K: J=4: K=7
REAL X,Y: X=2.3: Y=5.8
STRING A$,B$: A$="ABC": B$="DEF"
```

Numeric expressions use integer or real arguments and return an integer or real result:

2+3	Result is 5
2.0+3	Result is 5.0. Because 2.0 is a real constant, 3 is converted to real before performing the addition.
J/K+2	Result is 2. J/K evaluates to 0.
X*Y	Result is 13.34.
SQR(X*X+Y*Y)	Result is 6.23969

String expressions use string arguments and return a string result:

CONCAT$(A$,B$)	Result is "ABCDEF"

Relational expressions are used to make logical decisions in a program; they use the relational operators (>, <, =, etc.) and return a 0 or nonzero result:

3>5	Result is 0, since 3 is not greater than 5.
A$<>B$	Result is nonzero, since A$ is not equal to B$.

Bear BASIC is unlike many BASIC dialects in that it forces the user to declare the mode of each variable, thereby optimizing the compiler's speed. With all variables predeclared, the compiler is not forced to evaluate all expressions in floating point at run time (which is a very slow procedure), and then convert to integer as the need arises. Instead, the algorithms used in Bear BASIC attempt to evaluate all expressions in the output mode (the mode of the variable to which the expression is being assigned). To make it easier to write programs, Bear BASIC provides automatic mixed mode expression evaluation. This means that an expression may consist of a combination of real and integer values. Bear Basic will automatically convert the components of the expression to the proper mode before evaluating it, and will convert the result to the mode of the variable to which the expression is being assigned. This is very convenient for programmers; however, there are some important implications arising from it.

Whenever an expression is to be assigned to a real variable, then every component of that expression is evaluated in real mode. Components of the expression which are integer (for example, integer variables), are automatically converted to real before any arithmetic is performed. This conversion takes place entirely within temporary values in the compiler; the integer values themselves are not changed. Whenever a constant is specified with no decimal point, the compiler assumes that it is an integer value. Any constant designated with a decimal point will be assumed to be real. Since the process of converting an integer to a real is relatively slow, faster code will result with real operations when all real operands are specified.

Expressions are defined in terms of parentheses. Whenever an expression in parentheses is encountered, this is treated as a new expression, although it may be part of a larger expression. This has significance when expressions are being evaluated which will be assigned to integer arguments. When the compiler encounters a new expression (one with parenthesis), it attempts to evaluate that expression in the mode of the variable to which it will be assigned. In the case of a real operator this is not important, since all values are converted to real before any operation takes place. With integer variables, however, if any component of an expression is real, the rest of that expression will be converted to real before the operation takes place. A few examples will make this clear.

```
100  INTEGER A
110  A=(1/2)*2
```

In this case, the expression will evaluate to the value zero. All operations specified are integer. Integer operations take place by truncating the result, so 1 divided by 2 evaluates to 0.

```
100  INTEGER A
110  A=(1.0/2)*2
```

This expression also evaluates to zero, but for a different reason. The inner 1.0/2 evaluates to .5, but after the value is calculated, the compiler attempts to convert this back to integer to be in the proper mode for variable A. The integer version of 0.5 is 0.

```
100  REAL A
110  A=(1.0/2)*2.0
```

In this case, the expression will evaluate to 1. Each of the operations is real, so all operations take place in real mode.

```
100  INTEGER MOTOR                    ' DAC value to send to motor controller
110  REAL SPEED                       ' Speed setpoint for motor
120  SPEED=750.0                      ' Set to 750 RPM
130  MOTOR=(SPEED/100.0)*1023/10      ' Convert RPM to DAC value
140  DAC 1,MOTOR
```

This example illustrates the problem that can occur with real/integer conversions in expressions. In the example, it is assumed that DAC channel 1 is attached to a motor controller which accepts a 0 to 10 VDC input; each 1 VDC corresponds to 100 RPM (ie 3.4 VDC is 340 RPM). Line 130 converts the speed, given in RPMs, to the DAC value necessary to set the motor controller speed. Since the DAC statement works with integer values, it seems reasonable that MOTOR should be an integer. SPEED is a real, so we want the calculation to be handled using real numbers (result=767.25); the result should be truncated and stored in MOTOR (767). Unfortunately, when Bear BASIC evaluates the parenthesis, it converts the result at that point (7.50) to an integer (7), and then evaluates the rest of the expression in integer mode. The integer multiplication of 7*1023 causes a final result of 716. This is a relatively small error, but if the numbers that were being multiplied resulted in a value greater than 32767, then the integer overflow would cause the actual result to be quite far off.

By changing MOTOR to a real, the calculation in line 130 is performed as intended, providing a result of 767.25 to be stored in MOTOR. When the DAC statement is executed in line 140, MOTOR is truncated to 767, which is the expected result.

If MOTOR is left as an integer, and the parenthesis in line 130 are removed, then the correct result is also obtained. In this case, the entire calculation is performed in real mode, and then the result (767.25) is truncated and stored in MOTOR.

3.7 Statements

Statements describe the actions to be taken by the Bear BASIC program. Multiple statements can be placed in a line, separated by colons (':'). Statements can be grouped into seven categories: program flow, data storage, memory access, I/O, function definition, multitasking, and miscellaneous.

3.7.1 Program Flow Statements

Bear BASIC normally executes statements in linear order, as they are stored in the program. The following statements modify the program flow to allow code to be executed multiple times, to allow code to be shared, and to allow the program to make decisions.

CALL laddr [,arg...]	call an assembly language subroutine
CHAIN filenum or "fname"	load and run another program from EPROM
CHAIN "fname"	load and run another program from EPROM

FOR num=expr TO expr [STEP expr]	beginning of a program loop; see NEXT
GOSUB linenum	call a subroutine; see RETURN
GOTO linenum	jump to a line number
IF expr THEN	conditional execution of rest of line
NEXT	end of a program loop; see FOR
ON ERROR linenum	GOTO linenum if an error occurs
ON expr, GOSUB linenum [,linenum...]	call subroutine based on value of expr
ON expr, GOTO linenum [,linenum...]	jump to linenum based on value of expr
RETURN	continue at line following GOSUB
STOP	halt execution of program
SYSTEM laddr,regarray	call an assembly language subroutine

3.7.2 Data Storage Statements

These statements are used to declare the variables that are used in the program, and to embed data values in the program.

DATA arg [,arg...]	store data for READ to access
INTEGER varname [,varname...]	declare signed integer variables
READ arg [,arg...]	read values from DATA statements
REAL varname [,varname...]	declare floating-point variables
RESTORE	reset READ pointer to first DATA statement
STRING varname [,varname...]	declare text string variables

3.7.3 Memory Access Statements

These statements allow the programmer to directly access the Boss Bear memory.

CODE int [,int...]	store assembly language code in program
DEFMAP int	set memory map for POKE, PEEK, etc.
EEPOKE ee_addr,int	store a word in EEPROM
POKE laddr,byte	store byte at laddr
WPOKE laddr,int	store integer value at laddr

3.7.4 Input/Output Statements

Control applications depend upon input and output with the real world, and the Boss Bear supports a wide variety of I/O devices, so this is the largest group of Bear BASIC statements.

BBOUT chan,bin_val	send a data bit to an attached Bear Bones
CLS	erase the current FILE display device
CNTRMODE chan,int	set operating mode for counter
DAC chan,int	set D/A output level
DOUT chan,bin_val	control digital output channel
ERASE	erase the current FILE display device
FILE int	set current file I/O device
FINPUT fmt_str,arg	formatted INPUT from current FILE
FPRINT fmt_str,arg [,arg...]	formatted PRINT to current FILE

GETDATE month,day,year,wday	get current date from real time clock
GETIME hour,minute,second	get current time from real time clock
GOTOXY xpos,ypos	set cursor position for current FILE device
INPUT arg [,arg...]	wait for user input from current FILE
INPUT$ arg [,arg...]	allow commas in user input
INTERRUPT device,chan,task	attach a task to a hardware interrupt source
LOCATE row,col	set cursor position for current FILE device
NETMSG	send/receive network messages
NETWORK 0,unit,int,int,int,st	initialize Boss Bear network handler
NETWORK 1,type,reg,int,unit,reg,st	send registers to another Boss Bear
NETWORK 2,type,reg,int,unit,reg,st	read registers from another Boss Bear
NETWORK 3,type,reg,expr,st	set the value of a network register
NETWORK 4,type,reg,varname,st	read the value of a network register
OUT port,byte	send byte to hardware output port
PRINT arg [,arg...]	send output to current FILE device
RDCNTR chan,int,varname	read counter value into varname
SETDATE month,day,year,wday	set current date of real time clock
SETIME hour,minute,second	set current time of real time clock
WRCNTR chan,int,expr	write to counter register(s)

3.7.5 Function Definition Statements

Bear BASIC allows the programmer to extend the language by adding functions. See section 3.9 for a complete description.

DEF funcname [,arg...]	mark beginning of a user defined function
FNEND	mark end of a user defined function

3.7.6 Multitasking Statements

These statements support the multitasking ability of Bear BASIC, allowing the programmer to control which tasks are running and how often they are running.

CANCEL task	halt the rescheduling of a task
EXIT	abort execution of current task
JVECTOR laddr,task	store a jump instr. for an interrupt vector
PRIORITY int	set priority of current task
RUN task [,int]	begin task execution; set resched. interval
TASK task	mark the beginning of a task area
VECTOR laddr,task	store task number to an interrupt vector
WAIT int	suspend task execution for int tics

3.7.7 Miscellaneous Statements

DEBUG	halt compile process to display variables
INTOFF	disable all interrupt processing
INTON	enable all interrupt processing
RANDOMIZE	re-seed the random number generator

REM [string]	comment text
TRACEON	enable line number trace on current FILE
TRACEOFF	disable line number trace on current FILE

3.8 Functions

A function is called by referencing it in an expression. A function returns an integer, real, or string result. Functions can be grouped into five categories: math, string, memory access, I/O, and miscellaneous.

3.8.1 Math Functions

These include trigonometric, logarithmic, and bitwise logical functions.

ACOS (expr)	arccosine of expr
ASIN (expr)	arcsine of expr
ATAN (expr)	arctangent of expr
BAND (expr,expr)	bitwise logical AND of expr's
BOR (expr,expr)	bitwise logical OR of expr's
BXOR (expr,expr)	bitwise logical XOR of expr's
COS (expr)	cosine of expr
EXP (expr)	exponential function e**expr
LOG (expr)	natural logarithm (base e) of expr
LOG10 (expr)	common logarithm (base 10) of expr
RND	generate a pseudo-random number
SIN (expr)	sine of expr
SQR (expr)	square root of expr
TAN (expr)	tangent of expr

3.8.2 String Functions

These are used to work with strings and convert between strings and numbers.

ASC (strexpr)	ASCII equivalent of first char. in strexpr
CHR$ (expr)	one char. equivalent of expr
CONCAT$ (strexpr, strexpr)	appends second string after first
CVI (strexpr)	converts binary string to integer
CVS (strexpr)	converts binary string to real
LEN (strexpr)	length of strexpr
MID$ (strexpr,expr,expr)	substring of strexpr
MKI$ (expr)	converts an integer to a binary string
MKS$ (expr)	converts a real to a binary string
STR$ (expr)	converts a number to a string
VAL (strexpr)	converts a string to a number

3.8.3 Memory Access Functions

These functions allow the programmer to directly access the Boss Bear memory.

ADR (varname)	address of specified variable
EEPEEK (ee_addr)	read a word from EEPROM
PEEK (laddr)	read a byte from laddr
WPEEK (laddr)	read an integer value from laddr

3.8.4 Input/Output Functions

Each of these functions returns a value read from an input device.

ADC (chan)	A/D value for chan
BBIN (chan)	read a data bit from an attached Bear Bones
DIN (chan)	read digital input channel; 0 or 1
GET	waits for one byte from current FILE
INP (port)	reads a hardware output port
KEY	reads one byte from FILE, doesn't wait

3.8.5 Miscellaneous Functions

ERR	last error number generated

3.9 User Defined Functions

Bear BASIC supports multi-line user defined functions. A function definition may be any number of lines long. All functions must be defined as follows:

100 DEF *function_name* [*arguments*]
110 *function_definition*
120 FNEND

DEF indicates the start of a definition. **FNEND** indicates the end of a definition. The function name can be up to seven characters, following the rules for variable names. The function name must be declared in an **INTEGER**, **REAL**, or **STRING** statement. The function can have arguments, which are part of the **DEF** statement, but are not part of the **INTEGER**, **REAL**, or **STRING** statement where the function is declared. The arguments are true variables and must be declared. When the function is called, the parameters passed to the function will be copied to these variables so they should have unique names.

The following rules apply to user defined functions:

- Functions must be defined BEFORE they are used. It's a good idea to put all function definitions near the beginning of your program, after the variable definitions. If a function is referenced before it is declared, a FUNCTION ERROR will result.

- A maximum of 64 functions can be declared in one program.
- Function definitions cannot be nested. A FUNCTION ERROR will result if a **DEF** statement is found inside of a function definition.
- Function names must be unique. Do not use other variable names or names of Bear BASIC statements or functions (even a function name very close to a Bear BASIC reserved word may not be acceptable).
- Arrays cannot be used as arguments to functions. Only simple strings, reals, or integers are legal.
- Do not attempt to perform console inputs or outputs inside of a function if it will be used in a multitasking program. Your program may hang up since Bear Basic blocks console access during some multitasking operations.
- Functions are not recursive. A function cannot call itself, either directly or indirectly.

The result of a function can be assigned to the function name. To do this, in the function definition use an assignment statement to place the desired value in the function's name (ie. reference the function name like it was a variable name). In the assignment statement, do not specify the function's arguments on the left hand side of the "=" sign. For example, the following function returns the value 1:

```
100  INTEGER FN1
110  DEF FN1
120  FN1=1
130  FNEND
140  PRINT FN1                    ' The value 1 will be printed.
```

The following function returns the sum of its arguments:

```
100  INTEGER FN1,A,B,C
110  DEF FN1(A,B,C)
120  FN1=A+B+C
130  FNEND
140  PRINT FN1(1,2,3)             ' The value 6 will be printed.
```

Note that in line 120 the function is referred to without its arguments.

Here's another example. This function returns the left N characters of a string:

```
100  STRING LEFT$(127), A$(127)
110  INTEGER N
120  DEF LEFT$(A$,N)
130  LEFT$=MID$(A$,1,N)
140  FNEND
150  PRINT LEFT$("ABCDEF",3)       ' This prints "ABC"
```

One function can reference another. For example:

```
100  INTEGER FNA, FNB
110  DEF FNB : FNB=1 : FNEND
120  DEF FNA : FNA=FNB : FNEND
130  PRINT FNA                     ' This  prints "1"
```

If functions that are using strings call each other, the STRING SPACE EXCEEDED error can result if too many functions have partial string results stored in internal temporary storage.

If the message appears, you've called too many functions that need intermediate string storage. Simplify your code somewhat.

Chapter 4
Writing Control Applications in BASIC

This chapter is an introductory tutorial on using the Boss Bear for real time control applications. An example is provided to help clarify the programming and operation of the Boss Bear in a real application; it is a moderately complex control system that uses multitasking and the Bear Direct network interface. The program makes use of features which are described later in this manual, so the reader is advised to make use of the index when topics come up which haven't been covered previously.

4.1 Programming for Real Time Control Systems

The term 'real time control' implies that certain operations must be performed at particular times. This differs from the general application program, which is not timing dependent. For example, it doesn't matter too much whether a spreadsheet takes 1 second or 10 seconds to recalculate; on the other hand, it matters very much whether a motor controller ramps the motor speed down in 1 second or 10 seconds. Real time events fall into three categories: events that must happen before a specified time, events that must happen at a specified time, and events that must happen after a specified time. Real time control often involves managing multiple processes concurrently; in other words, several things may be happening at the same time.

4.1.1 The Primary Rule of Real Time Programming

At its simplest, real time programming can be reduced to one rule: the program cannot disregard any of the processes for too long. At any time that the program is waiting for an event to occur in one process, it must still be handling the other processes. The following example implements a system with two switches and two counters, with a counter being incremented when the corresponding switch is closed. This example breaks the rule by waiting for a switch to open, without continuing to check the other switch.

```
100  INTEGER C1, C2                ' Counter variables
105  C1=0: C2=0                    ' Initialize the counters to 0
110  IF DIN(1)=0 THEN 140          ' Continue if switch 1 not pressed
120  C1=C1+1                       ' Switch 1 pressed, increment counter
125  PRINT "C1 = "; C1
130  IF DIN(1)=1 THEN 130          ' Wait for switch 1 to be released
140  IF DIN(2)=0 THEN 170          ' Continue if switch 2 not pressed
150  C2=C2+1                       ' Switch 2 pressed, increment counter
155  PRINT "C2 = "; C2
160  IF DIN(2)=1 THEN 160          ' Wait for switch 2 to be released
170  GOTO 110                      ' Loop forever
```

This program almost works correctly. When no switch is closed, the program will loop from line 110 to line 140 to line 170 and back to line 110. If switch 1 is closed, then it will increment C1 and print the new C1 value in lines 120 and 125. It will then sit in a loop in line 130 until switch 1 is opened; when this happens, it will resume looping from 110 to 140 to 170, looking for a switch closure. Switch 2 and C2 are handled in the same manner. The problem occurs when it is waiting for a switch to be opened (lines 130 and 160). If it is looping in line 130, for instance, switch 2 could close and open while switch 1 remains closed, and the program would not detect the switch 2 closure. The following example handles this problem and counts

the two switches correctly.

```
100  INTEGER C(1)                    ' Counters
110  INTEGER S(1)                    ' Switch states
120  INTEGER J,K
130  C(0)=0: C(1)=0                  ' Initialize the counters to 0
140  FOR J=0 TO 1                    ' Loop for both switches
150    GOSUB 300                     ' Check for switch closure
160    IF K=0 THEN 190               ' Jump if no closure
170    C(J)=C(J)+1                   ' Increment counter
180    PRINT "C"; J;" = "; C(J)      ' Print counter
190  NEXT J
200  GOTO 140                        ' Loop forever
210  '
300  ' Subroutine to check for switch 'J' closure.  If the switch was previously
310  ' open and is closed now, then return a 1; otherwise, return a 0.
320  K=DIN(J+1)
330  IF K=1 AND S(J)=0 THEN S(J)=K: RETURN
340  IF K=0 AND S(J)=1 THEN S(J)=K
350  K=0: RETURN
```

This program is designed much better than the previous one; it is easily modified to handle more switches, by changing the size of the arrays 'C' and 'S' and the loop size in line 140. It constantly checks the state of both switches, incrementing the count when it detects that a switch has closed. Since it continues checking the state of both switches at all times, it won't miss a switch closure. The PRINT statement in line 180 will take about 5 milliseconds to complete (5 characters at 9600 baud). This means that it could miss a switch closure that lasts less than 5 msec; normally, a switch closure this short would be interpreted as a glitch, anyway, but it is still worth noting. In real time programming, any time delay must be examined to see how it affects the operation of the system.

The first program could be made to work correctly by using the multitasking feature of Bear BASIC. In the second example, extra code was written to allow the processor to perform two functions at once; actually it switched between them quickly to give the appearance of concurrent operation. This is precisely what the Bear BASIC context switcher does, so the program could be simpler if it took advantage of the context switcher. Two tasks would be written, with each one devoted to monitoring a switch. The following example demonstrates this technique; note that the two tasks are very similar to the two loops from the first example. Because each task gets 50 percent of the processor time, by executing every other tick, a switch state that is shorter than 10 msec (one tick) may be missed. For example, if the program is executing in line 210, and switch 2 toggles low and then high again 5 msec later, then when task 2 executes it will see input 2 high as if nothing had happened.

```
100  INTEGER C1, C2                  ' Counter variables
110  C1=0: C2=0                      ' Initialize the counters to 0
120  RUN 1
200  ' Handle first switch
210  IF DIN(1)=0 THEN 210            ' Wait for switch 1 to be pressed
220  C1=C1+1                         ' Switch 1 pressed, increment counter
230  PRINT "C1 = "; C1
240  IF DIN(1)=1 THEN 240            ' Wait for switch 1 to be released
250  GOTO 210                        ' Loop forever
300  ' Handle second switch
305  TASK 1
310  IF DIN(2)=0 THEN 310            ' Wait for switch 2 to be pressed
320  C2=C2+1                         ' Switch 2 pressed, increment counter
330  PRINT "C2 = "; C2
340  IF DIN(2)=1 THEN 340            ' Wait for switch 2 to be released
```

```
350  GOTO 310                        ' Loop forever
```

4.1.2 Managing Timing in a Control System

Obviously, one of the most important functions of a real time program is to ensure that control operations happen at the proper time. Bear BASIC provides three methods for handling real time scheduling of operations: the real time clock, the WAIT statement, and the hardware timer. Each of these covers different areas of real time scheduling.

With a resolution of one second, the real time clock is only useful for handling relatively long time periods. This makes it ideal for keeping track of down-time, run-time, shift totals, daily totals, and other long term production statistics. Care must be used when programming with a real time clock, because of the possibility of wrap-around at the end of the minute, end of the hour, and end of the day. Also, the programmer must be aware of the size of numbers that result when working with time of day values; for example, there are 86400 seconds in a day, which means that an integer won't hold an entire day in seconds. The following example shows how to handle the real time clock for long time periods:

```
100  ' Example to demonstrate using the real time clock to measure
102  ' long time intervals.

110  INTEGER HA, MA, SA
120  INTEGER J, K, FLAG1, END1

130  FLAG1=0

190  ' When input 1 turns on, turn on output 1.  When input 1 turns off,
192  ' wait for 140 seconds, then turn off output 1.
200  J=DIN(1)
210  IF J=0 AND FLAG1=0 THEN 200        ' Input off, keep waiting
220  IF J=1 AND FLAG1=1 THEN 200        ' Input on, keep waiting
230  IF J=0 THEN 300                    ' Jump if input just turned off
240  ' Input just turned on, so turn on output
250  DOUT 1,1
260  FLAG1=1
270  GOTO 200

300  ' Input just turned off, so wait for 140 seconds, then turn off output 1.
310  GETIME HA,MA,SA                    ' Get current time
320  END1=MA*60+SA+140                  ' Calculate end time (cur.time+140)
330  IF END1>3599 THEN END1=END1-3600   ' Convert to 0-3599 range
340  GETIME HA,MA,SA
350  IF MA*60+SA <> END1 THEN 340       ' Wait for 140 seconds to pass
360  DOUT 1,0
370  FLAG1=0
380  GOTO 200
```

In order to execute a 140 second delay, the program reads the real time clock in line 310. It converts the minutes (0-59) and seconds (0-59) to just seconds (0-3599), and adds in the 140 second delay time. This could result in a number larger than 3599, so it checks for this in line 330, wrapping the result around if it is larger than 3599. The program then loops in lines 340 and 350, waiting for the 140 seconds to pass.

With a resolution of approximately 10 msec, the WAIT statement is suitable for medium time intervals, on the order of 20 msec to 300 seconds. In a multitasking program, it can be

difficult to predict exactly what time delay a particular WAIT statement will generate, since it depends upon what the other tasks are doing at the time, as well as the relative priorities of all of the tasks.

For critical timing functions, the Boss Bear relies on the hardware timer (the Z180's internal timer 1), which has a resolution of a few microseconds. Because of the way Bear BASIC works internally, the fastest time interval that can be reliably handled is 1 millisecond. The timer can be read periodically by the BASIC program to perform its timing functions, or a timer interrupt handler can be set up. Note that the timer is a 16 bit integer number that rolls over approximately 5 times per second. The following example shows how the WAIT statement timing can vary, and how to read the timer to measure small time intervals:

```
105  INTEGER X,RL,RLL,RLH
110  INTEGER TIMER
120  INTEGER T2,T3

200  GOSUB 1000                          ' Start the timer running
210  RUN 2
220  RUN 3,1
230  T2 = 0

300  TIMER = 0                           ' Reset the timer value
310  WAIT 50                             ' Wait for 50/100 second
320  PRINT TIMER                         ' Display length of WAIT in msec
330  GOTO 300

1000 VECTOR $E6,1                        ' Set up timer vector to task 1
1020 RL=6144000.0 / 20.0 / 1000.0        ' 1000 ints/sec reload value
1030 RLH=RL / $100: RLL=BAND(RL,$FF)
1040 OUT $14,RLL: OUT $15,RLH            ' Init timer value
1050 OUT $16,RLL: OUT $17,RLH            ' Init reload value
1060 OUT $10,BOR(INP($10),$22)           ' Enable timer 1
1070 RETURN

1100 ' Timer interrupt task.  Called 1000 times per second by hardware
1102 ' timer 1.
1105 TASK 1
1110 X=INP($10): X=INP($14)              ' Reset the timer 1 interrupt flag
1120 TIMER=TIMER + 1                     ' Increment global timer value
1130 EXIT                                ' End of timer interrupt task

2000 TASK 2
2010 T2 = T2 + 1
2020 IF T2 = 10000 THEN PRIORITY 1       ' Bump to higher priority for a while
2030 IF T2 = 20000 THEN T2=0: PRIORITY 0 ' Back to original priority
2040 GOTO 2010

2100 TASK 3
2110 FOR T3 = 1 TO 8000                  ' Delay for a while, then exit
2120 NEXT T3
2130 EXIT
```

This program sets up a timer interrupt task to execute 1000 times per second. Timer 1 and the interrupt are initialized in lines 1000 to 1070. Task 1 is the timer interrupt task; it simply resets the timer hardware's interrupt flag and then increments the TIMER variable. Lines 300 to 330 perform a 50 tick (500 msec) WAIT, then print the actual number of milliseconds that the WAIT took to complete. Task 2 just increments a variable, and periodically sets its priority to a higher value, causing task 0 and task 3 to be suspended until task 2 resets its priority. Task 3 executes a short loop (to waste some time) and then exits, to be restarted

after 1 tick. When task 2 sets itself to a higher priority, the task 0 WAIT statement will take much longer than 50 ticks (about 300 ticks), because task 0 can't be run, even though it is ready to run after the 50 tick waiting period. Periodically, task 3 will be ready to run when the task 0 WAIT statement completes; task 3 will run before task 0 gets to run, causing an extra tick to pass before task 0 executes. The following output was produced when this program was run; it shows both of these effects:

```
502
495
506
495
505
496
495
505
496
505
2942
495
505
495
496
505
496
506
```

4.2 Project Specification

The project specification is an extremely important element of the control system design. A complete, well thought out specification will increase the reliability of the system, and can dramatically decrease the implementation time for the system. The ideal specification would completely describe all components of the system in enough detail to allow an independent party to construct the system; this should be the goal of the specification writer. In reality, of course, this is not possible; questions will always arise during the project implementation that had not been previously considered.

The exact contents of the specification depend on the project, but in general the following elements should be included:

General description of application. Ideally, this will be detailed enough that someone who is not familiar with the application will be able to understand it.

Input/Output requirements. List the inputs and outputs required to support the application, including parameters such as voltage, current, pulse rate, temperature, etc.

Screen and report formats. List the layout of any display screens or printed reports. This should be done on grid paper to ensure that the text will fit in the available space.

Timing requirements. List any timing requirements, including both timing required for hardware reasons and timing desired by the user. For a machine control application, this could include machine cycle time, setup time, motor speed,

minimum speed ramp time, sample rate for a control parameter, etc. For an application that uses a personal computer, this could include file access times, network poll rate, screen update speed, etc. Remember that minimum and maximum times can both be important.

Mechanical requirements. List any special mounting or size requirements. This may also include mechanical information about the machinery that will be interfaced to.

Environmental requirements. List the operating and storage environment for the system. This includes temperature, humidity, radiation, etc.

Hardware requirements. This is a list of hardware items to be used or interfaced with. Include a note as to the reason for the requirement (ie. because it is a standard part already in inventory, or because it is the only part that meets a particular specification). Include exact part numbers, if possible.

Software requirements. This is a list of software packages to be used or interfaced with. Include a note as to the reason for the requirement. Note any special hardware that may be required by this software (ie. math coprocessor, modem).

Initial system testing. List the items that should be tested "in the lab", including the verification procedure for each item.

Final system testing. List the items that should be tested "in the field", including the verification procedure for each item.

4.3 Real Time Programming Example

Many aspects of software design only come to light in larger programs. This section demonstrates the use of Bear BASIC by implementing a realistic example program. The goal is to develop a program that will perform a typical industrial control operation. Portions of this program will be useful in the user's own programs. The example goes through the project specification, program development, and system testing phases.

This example is based on a hypothetical rewind machine in which the product is drawn off of an input roll and rewound onto shorter output rolls. The output rolls are wound onto cores which feed in from a hopper. The product wraps onto the core as the machine speed ramps up. The machine runs at operating speed until it nears the end of the output roll, then the speed is ramped down. When the machine stops, a knife cuts the product and a gate opens, allowing the output roll to fall onto a conveyor belt to be taken away. Several pieces of production data must be maintained by the Boss Bear, in order to be uploaded to a personal computer at the end of each shift. The operator will enter operating parameters into the Boss Bear using the keypad; the display will indicate the current status of the rewind operation.

4.3.1 Example Project Specification

The following specification shows the level of detail that should be the goal of the system designer. In practice, much of this information is often only expressed verbally, which may be acceptable if the project is small or if everyone involved has experience with the application. In a larger project, or if some parties are unfamiliar with the application, then a detailed specification will help to prevent misunderstandings. Typically, a specification such as the following example would be arrived at through discussions between the client and the programmer. The example is printed in courier 12cpi to distinguish it from the rest of the text.

General description of application.
A control system is needed for a new rewind machine which is being constructed. The machine pulls the product off of an input roll. The input roll will be approximately 3000 yards long and 2.5 feet in diameter. Each product number has a preset length, between 10 and 30 yards, associated with it; this length of product will be wound onto each output roll. The Boss Bear is attached to the main drive motor; it ramps the speed up, winds at a preset speed, and ramps the speed down. A shaft encoder (quadrature, with A, B, and MARK outputs) will be used to measure the main drive motion. The ramp down must be calculated so that the main drive stops within 0.25 inches of the selected length. When the main drive is stopped, the Boss Bear will cause a knife to cut the product and then retract. A gate is then opened to allow the output roll to drop onto a conveyor to be taken away; two optical sensors are positioned to detect that the roll drops. The gate is closed, then another gate is opened to allow a new core to drop into position from a hopper above the machine. The operator attaches the product tail to the core then presses the RUN pushbutton to start the rewind operation again.

If an error is detected, then the machine will be stopped and an error message will be displayed on the Boss Bear; the operator will correct the error condition, insert a new core, and press the RUN pushbutton to start a new roll.

The user interface will consist of the Boss Bear keypad and display, the RUN pushbutton, and the emergency stop switch (ESTOP). The operator enters the product number, batch number, input roll length, operator number, and downtime code from the keypad. The display will show the remaining product on the input roll and the number of output rolls produced. When the input roll is removed, the Boss Bear will display the number of yards left (if any) on the input roll; the operator will write this on a tag to go on the roll. If it takes longer than 60 seconds after a roll is produced for the operator to press the RUN button, then the Boss Bear will accumulate downtime (in seconds); the operator must enter a downtime code before the machine can be run again. One of the downtime codes is "maintenance"; if this is entered, then the machine can be run, but no production data will be collected.

Production data is collected and transferred over the Bear Direct network periodically to a personal computer (PC). Each time that the operator enters a new product number or batch number, the totals for the previous product/batch are sent to the PC. At the end of the shift, the shift totals are collected by the PC.

The table of product lengths will be stored as part of the Boss Bear program, since no new products will be added in the foreseeable future.

Input/Output requirements.
Hardware I/O points:

- Shaft encoder. This is a 600 pulse/rev biphase optical shaft encoder. The mechanical coupling with the machine produces 50 pulses per inch of material. It is connected to the Boss Bear's onboard counter.
- Motor control. This is a -10 to 10 VDC analog signal to control the main drive speed; -10 VDC corresponds to 0 RPM, and 10 VDC corresponds to

approximately 10 feet/second. This is connected to a DAC module on the Boss Bear.
- Knife output. This is a discrete output that causes the knife to cut the material when the output turns on. This output should stay on for approximately 200 msec.
- Optical sensor input. This is a discrete input that is connected to two optical sensors (with open collector outputs), that show when a roll is in place in the machine.
- Conveyor gate output. This is a discrete output that causes the lower gate to open, allowing the output roll to fall onto the conveyor. This output should stay on for approximately 200 msec after both optical sensors show that the roll has moved.
- Core hopper gate output. This is a discrete output that causes the upper gate to open, allowing the core to fall into place. This output can turn off as soon as both optical sensors show that the core is in place.
- RUN pushbutton input. This is a discrete input attached to a momentary pushbutton mounted near the operator's position.
- Emergency stop pushbutton input. This is a discrete input attached to a push-pull switch near the operator's position. Other poles of the emergency stop switch are connected to hardware failsafe systems; this input just informs the Boss Bear that the system has been stopped.

User input values:
- Product number. This is an integer number (0..9999) which the operator enters at the start of a product run.
- Operator number. This is an integer number (0..999) which the operator enters at the start of the shift.
- Input roll length. This is an integer number (0..9999) which the operator enters when a new input roll is mounted on the machine. It is the length of the input roll in yards.
- Batch number. This is an integer number (0..999999) which the operator enters at the start of a new batch.
- Downtime code. This is a number entered by the operator when the machine is stopped for more than 60 seconds. The operator will be prompted for the following downtime codes: Maintenance, break time, input roll loading, and machine jam.

Display output values:
- Output roll count for product. This is an integer number (0..99999) which shows the number of output rolls produced for this product so far in this shift.
- Output roll count for batch. This is an integer number (0..99999) which shows the number of output rolls produced for this batch so far in this shift.
- Number of yards left on the input roll. This is an integer number (0..9999) which shows the number of yards left on the input roll. This is calculated by subtracting the number of yards run through the machine from the input roll length; if the result is less than 0, then 0 should be displayed.

Network transfer values:
- Current product number.
- Current batch number.
- Current operator number.
- Total downtime thus far in shift.
- For each product completed, the product number, total number of rolls, and total yards are sent to the PC.
- For each batch completed, the batch number, total number of rolls, and total yards are sent to the PC.
- The shift totals for number of rolls, number of yards, and downtime (per category) are retrieved by the PC at the end of each shift. The operator number for the completed shift is also retrieved by the PC at the end of the shift.

Screen and report formats.
The display formats are not critical. The normal operating display will be similar to this:

```
Product # XXXX    Batch # XXXXXX
```

```
      Prod:XXXXX  Batch:XXXXX  Yds left: XXXX
```

The format of any other displays may be chosen by the programmer.

Timing requirements.
The throughput of the machine should be maintained at the highest practical value. The operator should be able to enter the maximum run speed from the keypad. Other than these requirements and any previous constraints, there are no critical timing requirements.

Mechanical requirements.
The Boss Bear, its power supply, and any auxiliary equipment (excluding sensors) will be mounted in a NEMA 4 enclosure, approximately 12 inches wide by 16 inches high by 6 inches deep. All wiring will enter the enclosure through 0.75 inch holes punched in the bottom surface. All field wiring will terminate at screw-type terminal strips.

Environmental requirements.
The machine will be located in a normal factory environment.

Hardware requirements.
The optical shaft encoder and motor drive controller are being supplied by the customer; specifications are enclosed separately for these items. 120VAC will be brought into the enclosure; the Boss Bear and all I/O devices will be powered from the 120VAC source. Proper steps should be taken to ensure noise immunity and electrical isolation.

Software requirements.
The data should be stored on the PC in a Lotus 123 compatible file format, to facilitate post-processing of the data.

Initial system testing.
As much testing as is feasible will be performed prior to mounting the system on the actual machine. A shaft encoder will be provided for initial testing. The motor drive will not be available for initial testing.

Final system testing.
A machine will be made available for approximately two working weeks for system testing. An electrician and maintenance technician will be available during this time. The machine will undergo a five day acceptance period, during which it will be run under normal production conditions.

Often, during the engineering implementation, the specification must be changed in response to problems, new information, parameter changes, personal whims, etc. The actual printed specification should be updated and distributed to all interested parties when changes occur. This will help to avoid nasty surprises on anyone's part. Unfortunately, it is often not until a project has started to fall apart that the specification (or lack of one) becomes important.

4.3.2 Initial Software Design

For an experienced programmer, most of the initial phase of the software design occurs while reading the specification and while sitting in meetings. This is the part of the design where the overall structure of the program is laid out and data structures are chosen. For the less experienced programmer, it is often useful to consider this as an independent phase. The natural inclination for most people is to jump in and start writing the program; this often leads to programs which are confusing to read and hard to debug. As with the specification, a little bit of thought up front can save hours of frustration later.

Many different techniques can be used to lay out the structure of a program, such as flow charting, data flow diagrams, state descriptions, etc. Each of these has been the focus of entire books, and so won't be discussed in detail here. Primarily, the structure of a program depends upon two things: determining which actions must be performed sequentially (one following another), and determining which actions must be performed concurrently (taking place at about the same time). Drawing a state diagram will point up any concurrency issues in a design. The example program can be divided into 8 main states of operation. Some of these states could be broken down again into another level of state diagrams, but for a simple program like this one, it won't be necessary. Here are the main states:

1. Program initialization. Set up the program variables and system hardware prior to performing any control functions. Unless problems are detected which prohibit the system from being used, this goes to state 4.
2. Running a product roll. Using the specified product length, calculate the motor ramping parameters. Ramp the motor speed up to the preset operating speed, run until it reaches the ramp-down point, and ramp the motor speed down to a full stop. Cut the product by enabling the Knife output for 200 msec. Drop the product onto the conveyor belt. Drop a new core into position. This goes to state 3.
3. Update current production data. If not in maintenance mode, then update the current production totals. Update the display with the current number of rolls produced and the amount of material left on the input roll. This goes to state 4.
4. Operator data entry. Based on the function key that was pressed, prompt the operator to enter a product number, operator number, input roll length, or batch number. If a new product number or batch number is entered, then go to state 6. This goes to state 2 when the RUN pushbutton is pressed. If no operation is performed for 60 seconds, then this goes to state 5.
5. Downtime accumulation. Display the downtime codes. Accumulate downtime while waiting for the operator to enter a downtime code. When a downtime code is selected, this goes to state 4.
6. Transfer product/batch data over the network. When a new product or batch number has been entered, then the appropriate data is transferred to the central computer. This goes to state 4.
7. Transfer shift data over the network. When the central computer requests the shift end totals, transfer the data to it. This can occur while in any of states 2, 3, 4, 5, 6, or 8.
8. Emergency stop. Put all outputs into a safe state. Wait for the emergency stop pushbutton to be released. This can occur while in any of states 2, 3, 4, 5, 6, or 7.

Figure 4 graphically shows the relationship between the states. Note that two of the states ("8 Emergency stop" and "7 Transfer shift data over the network") aren't shown connected to any other states. These two states can be entered at any time, based on outside events

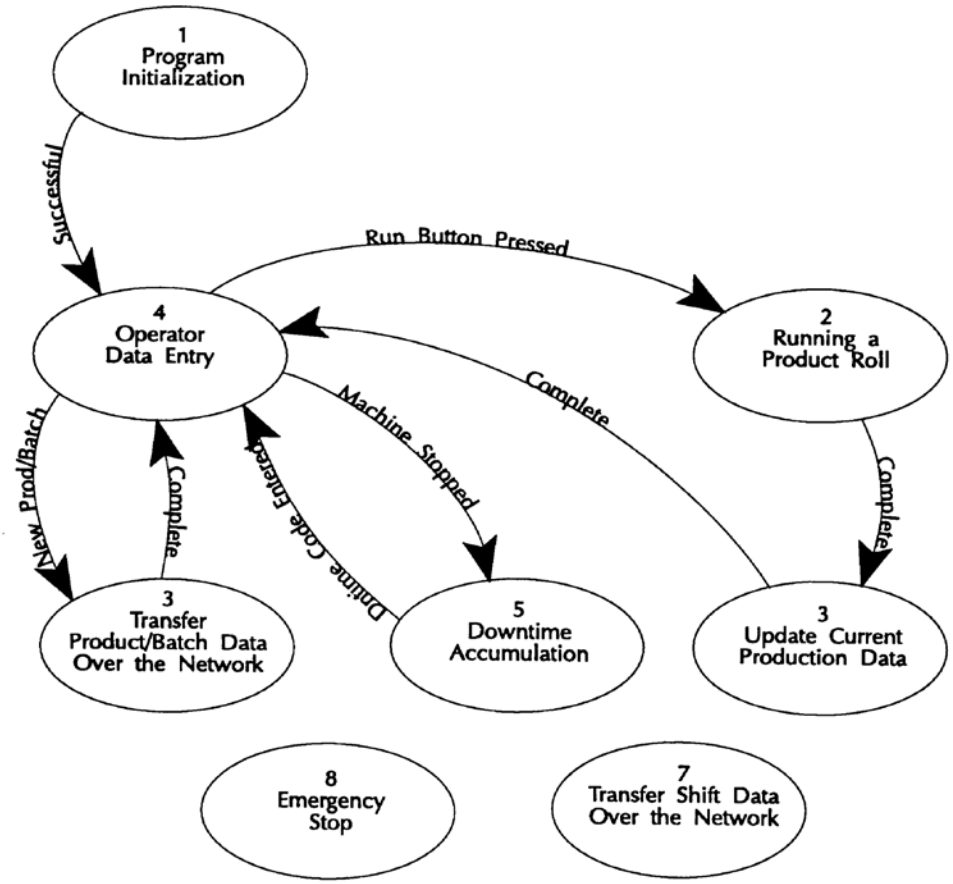


Figure 4 – State Diagram for Example Program

that occur asynchronously to the Boss Bear control program. In other words, they operate concurrently with the rest of the program. This makes them likely candidates for being implemented as individual tasks in the program.

It is important to plan the program's data structures before writing the program. The term "data structure" refers to the way that the program's data is stored in variables. Data structure choices can have a huge effect on the operation of a program, both in terms of programming complexity and of runtime size and speed. Control applications generally have relatively simple data structures, but it still makes the programming go more smoothly if they are laid out before hand. A list of variables should be made to show the name of each variable, its type (integer, real, or string), a description, and a valid range (ie. 0.0 to 9.99). Note that the way a value is stored is often not the way that it is entered or displayed; for example, a number that may range from 0.0 to 99.9 may actually be stored as an integer between 0 and 999, to save space. This list doesn't need to show the

temporary variables used within the program, such as loop counters, intermediate results, etc. The following is a preliminary list of variables that will be needed for the example program:

INLEN	Input roll length. A number in the range (0..9999); it is stored as an integer.
PRDNUM	Product number. A number in the range (0..9999); it is stored as an integer.
OPNUM	Operator number. A number in the range (0..999); it is stored as an integer.
BATNUM	Batch number. A number in the range (0..999999); it is stored as a text string.
LENSETP	Length setpoint for the current product, in shaft encoder pulses (1/50's of an inch); over the 10 to 30 yard range of output roll length, this yields a number in the range (18000..54000). It is stored as a real.
CURLEN	Length of current roll being run, in shaft encoder pulses (1/50's of an inch). A number in the range (18000..54000). It is stored as an integer.
DNTIME()	Array of current downtime totals. There are four downtime codes, for which downtime is accumulated separately in seconds over a shift, which is a range of (0..28800). This is an integer array.
TOTDNTM	Total downtime thus far in the shift, in seconds. A number in the range (0..28800); it is stored as an integer.
RROLCNT	Output roll count for current input roll. A number in the range (0..1000); it is stored as a real.
PROLCNT	Output roll count for product. A number in the range (0..99999); it is stored as a real.
PYARDS	Output roll total yards for product. A number in the range (0..9999); it is stored as a real.
BROLCNT	Output roll count for batch. A number in the range (0..99999); it is stored as a real.
BYARDS	Output roll total yards for batch. A number in the range (0..9999); it is stored as a real.
SROLCNT	Output roll count for shift. A number in the range (0..99999); it is stored as a real.
SYARDS	Output roll total yards for shift. A number in the range (0.9999); it is stored as a real.

4.3.3 Rewind Program Example

```
new
download

100  ' REWIND.BAS - Demo program for Boss Bear rewinder control
     '
     '
     '****************************************************************
     ' Network register usage:
     ' I0      current product number
     ' I1      current operator number
     ' S0      current batch number
     ' I2      total downtime thus far in shift
     '
     ' I10     last product: new data available flag
     ' I11     last product: product number
     ' R10     last product: total number of rolls
     ' R11     last product: total yards
     '
     ' I20     last batch: new data available flag
     ' S1      last batch: batch number
     ' R20     last batch: total number of rolls
     ' R21     last batch: total yards
     '
     ' I30     shift end: end of shift flag
     ' I31     shift end: data available flag
     ' R30     shift end: total number of rolls
     ' R31     shift end: total yards
     ' I32     shift end: operator break downtime total
     ' I33     shift end: input roll downtime total
     ' I34     shift end: machine jam downtime total
     ' I35     shift end: maintenance downtime total


     '****************************************************************
     ' Variable declarations

     integer inlen       ' Input roll length.  (0..9999)
     real ydsleft        ' Yards left on roll (0.0..9999.0)
     integer prdnum      ' Product number.  (0..9999)
     integer opnum       ' Operator number.  (0..999)
     string batnum$(6)   ' Batch number.  (0..999999)
     real lnsetp         ' Length setpoint, 1/50's of an inch (18000..54000)
     integer curlen      ' Length of current roll, 1/50's inch (18000..54000)
     integer dntime(3)   ' Current downtime totals.  (0..28800)
                         '   0 = operator break time
                         '   1 = change input roll
                         '   2 = machine jam
                         '   3 = machine maintenance
     integer totdntm     ' Total downtime for shift
     real rrolcnt        ' Output roll count for input roll (0..1000)
     real prolcnt        ' Output roll count for product.
     real pyards         ' Total yards for product.
     real brolcnt        ' Output roll count for batch.
     real byards         ' Total yards for batch.
     real srolcnt        ' Output roll count for shift.
     real syards         ' Total yards for shift.
     integer maintmd     ' 1 if in maintenance mode, otherwise 0
     integer estopmd     ' 1 if in emergency stop mode, otherwise 0

     integer hour, min, sec, sttime
     integer dhour, dmin, dsec

     ' Control loop variables
     real curpos         ' Counter value indicating position in roll
     real spd
```

```
     real accelrt
     real decelrt
     real maxspd
     real decelpt

     ' I/O redirection variables.  These are constant values that hold the
     ' channel number corresponding to each I/O function.  This makes it
     ' easy to change the I/O layout, if necessary.
     integer IRUNBUT                    ' Operator run pushbutton
     integer IESTOP                     ' Emergency Stop switch
     integer IOPTIC                     ' Optical sensor for core in position
     integer OMDRV                      ' Main drive enable
     integer OKNIFE                     ' Knife output
     integer OCONV                      ' Conveyor gate
     integer OCORE                      ' Core hopper gate

     ' Variables for user interface code.
     integer flush                      ' User defined function name
     integer flshtem                    ' Temp used by 'flush'
     integer ch                         ' User interface temp
     integer timeout, delay             ' User interface timeout variables
     integer K, uivlu, uilen
     real uirvlu
     string uifmt$(50), uifmt2$(50)
     string uisvlu$

     ' Temporary scratchpad variables.
     integer temp, a, b, c              ' Miscellaneous integer temps
     integer done
     integer t1tmp
     integer t2, t2st
     integer st
     real ftemp                         ' Real temp
     string tempstr$(40)                ' String temp


     '*****************************************************************
     ' DATA statements
     data 1000, 18000.0                 ' Product # 1000, 360.0 inches
     data 1001, 36000.0                 ' #1001, 720.0 inches
     data 1002, 5400.0                  ' #1002, 108.0
     data 1003, 5450.0                  ' #1003, 109.0

     data -1                            ' End of table flag

500  '*****************************************************************
     ' Function definitions

     ' Flush the keypad buffer and wait for a key to be pressed
     ' Returns: key pressed
     ' Modifies: flshtem
     def flush
       wait 10
520    if din($100) <> 0 then goto 520
       wait 20
530    if key <> 0 then goto 530
540    flshtem = din($100): if flshtem = 0 then 540
       flush = flshtem
     fnend


800  '*****************************************************************
     ' Initialization
     file 6                             ' Use onboard display
     ' Set timeout delay to 30 seconds for waiting on the users input
     delay = 300

     IRUNBUT = 1                        ' RUN button is on input 1
```

```
     IESTOP = 3                          ' Emergency Stop switch
     IOPTIC = 2                          ' Optical sensor
     OMDRV = 7                           ' Main drive enable is on output 7
     OKNIFE = 1                          ' Knife output
     OCONV = 2                           ' Conveyor gate output
     OCORE = 3                           ' Core hopper gate

     maintmd = 0                         ' Not in maint. mode to start with
     for a = 0 to 3
       dntime(a) = 0
     next a

     if len(batnum$) > 6 then batnum$ = "000000"
     if prdnum < 0 or prdnum > 9999 then prdnum = 0

     maxspd = 300.0
     accelrt = 200.0
     decelrt = 500.0
     totdntm = 0
     estopmd = 0                        ' Not in emerg. stop mode to start with
     cntrmode 1,1                        ' Quadrature X1 mode

     dout 5,1: dout 6,1                  ' Enable shaft encoder inputs
     dout 0,1                            ' Set counter reset/latch to reset

     run 1,2                             ' Start emergency stop task
     run 2,2                             ' Start shift end task

     a = eepeek(1)                       ' Get unit number
     network 0,a,50,50,2,b               ' Initialize network with 50 integers,
                                         ' 50 reals, and 2 strings

1000 '*************************************************************
     ' Mainline loop.  This is where we sit while waiting for the
     ' operator to press a key or hit the RUN pushbutton.  If it sits
     ' here for more than 60 seconds, then gosub 4000 to accumulate
     ' downtime.
     getime hour,min,sec
     sttime = min*60+sec                 ' Save start time
     gosub 8100                          ' Display fixed part of main screen

1020 ch = key
     if ch = $41 then gosub 1200: goto 1000
     if ch = $42 then gosub 4300: goto 1000
     if din (IRUNBUT) then gosub 2000: goto 1000

     ' Don't look for downtime if currently in maintenance mode.
     if maintmd then 1020

     ' Has it been 60 seconds?  Don't forget to handle hour wrap-around.
     getime a,b,c
     a = b * 60 + c
     if a-sttime < 0 then sttime = sttime-3600
     if a-sttime > 60 then gosub 4000: goto 1000
     goto 1020


1200 '*************************************************************
     ' Operator Data Entry
     erase

     uifmt$ = "Batch Number > ": uisvlu$ = batnum$: uilen = 6
     gosub 8600: if K = 0 then 1250

     network 3,2,1,batnum$,a             ' Store batch number
     network 3,1,20,brolcnt,a            ' Store batch roll count
     network 3,1,21,byards,a             ' Store batch yards
     network 3,0,20,1,a                  ' Set "data available" flag
```

```
     batnum$ = uisvlu$
     brolcnt = 0.0                      ' Clear batch roll count
     byards = 0.0                       ' Clear batch yards count
     network 3,2,0,batnum$,st           ' Store batch number in network var.

1250 uifmt2$ = "I4"
     uifmt$ = "Product Number (0-9999) > ": uivlu = prdnum
     gosub 8300: if K = 0 then 1400

     ' The operator typed a product number in, so we need to see if it
     ' is in the list.
     restore
1300 read a
     if a = uivlu then 1370
     if a <> -1 then read a: goto 1300

     ' Looked through entire DATA table and didn't find it, so display
     ' a message and let the operator try again.
     erase
     print "Unknown product number entered";
     wait 200: goto 1250

     ' Found it, so update the network registers, read the length setpoint,
     ' and continue.
1370 network 3,0,11,prdnum,a            ' Store product number
     network 3,1,10,prolcnt,a           ' Store product roll count
     network 3,1,11,pyards,a            ' Store product yards
     network 3,0,10,1,a                 ' Set "data available" flag

     prdnum = uivlu                     ' Update product number
     read lnsetp                        ' Read the new length setpoint
     prolcnt = 0.0                      ' Clear the roll count
     pyards = 0.0                       ' Clear the yards count
     network 3,0,0,prdnum,st            ' Store product number in network var.

1400 uifmt$ = "Input Roll Length (1-9999) > ": uivlu = inlen
     gosub 8300: if K = 0 then 1450
     inlen = uivlu
     rrolcnt = 0
     ydsleft = inlen

1450 uifmt$ = "Operator Number (0-9999) > ": uivlu = opnum
     gosub 8300: if K = 0 then 1490
     opnum = uivlu
     network 3,0,1,opnum,st            ' Store operator number in network var.

1490 return


2000 '************************************************************
     ' Run a Product Roll
     if estopmd then 2990               ' EStop, so don't run!

     ' Start main drive moving slowly
     wrcntr 1,0,0
     dac 1,580
     dout OMDRV,1                       ' Enable main drive
     wait 10

     ' Main drive control loop to run specified length.  This ramps the
     ' drive speed up to its running speed, runs until it gets close to
     ' the stop point, then ramps the drive back down to 0, stopping
     ' when it reaches the correct length.
2050   rdcntr 1,2,curpos                ' Read current position in roll
       spd = curpos / accelrt * 51.1
       if spd > maxspd then spd = maxspd
       decelpt = (lnsetp - curpos) / decelrt * 51.1
```

```
      if spd > decelpt then spd = decelpt
      if spd < 20.0 then spd = 20.0    ' Maintain a minimum speed
      if spd > 500.0 then spd = 500.0
      if estopmd then 2990             ' EStop button pressed, so exit
      dac 1,spd + 512.0
    if curpos < lnsetp then 2050

    ' Reached the specified length, so stop the main drive.
    dac 1,512
    dout OMDRV,0                       ' Disable main drive
    ' Cut the product
    dout OKNIFE,1
    wait 20
    if estopmd then 2990
    dout OKNIFE,0

    ' Drop the product onto the conveyor
    erase
    print "Waiting for roll to drop onto conveyor"
    dout OCONV,1
2100 if estopmd then 2990
    if din(IOPTIC) = 1 then 2100
    dout OCONV,0

    ' The roll was successfully produced, so update production statistics
    gosub 3000

    ' Drop a new core into position
    erase
    print "Waiting for core to drop from hopper"
    dout OCORE,1
2150 if estopmd then 2990
    if din(IOPTIC) = 0 then 2150
    dout OCORE,0

2990 ydsleft = ydsleft - lnsetp / 50.0 / 36.0
    if ydsleft < 0.0 or ydsleft > inlen then ydsleft = 0.0
    return


3000 '*************************************************************
    ' Update Current Production Data
    rrolcnt = rrolcnt + 1
    if maintmd then 3490

    ftemp = lnsetp / 50.0 / 36.0       ' Calc length of roll in yards

    brolcnt = brolcnt + 1.0            ' Update batch total
    byards = byards + ftemp            ' Update batch yards
    prolcnt = prolcnt + 1.0            ' Update product total
    pyards = pyards + ftemp            ' Update product yards
    srolcnt = srolcnt + 1.0            ' Update shift total
    syards = syards + ftemp            ' Update shift yards

3490 return


4000 '*************************************************************
    ' Downtime Accumulation.  Wait for the operator to select a downtime
    ' code, then add current downtime to that downtime total.  Note
    ' that maintenance downtime is a special case; it sets the 'maintmd'
    ' flag and returns, so that the machine can still be run.
    erase
    print "F1-Break    F2-Input Roll    F3-Jam"
    print "F4-Maintenance";
    dhour = hour
    dmin = min
    dsec = sec
```

```
4030 ch = get
     if ch < $41 or ch > $44 then 4030
     if ch = $44 then 4100
     ch = ch - $41
     gosub 4400                          ' Update downtime array

     erase
     if ch = 0 then print "Break";
     if ch = 1 then print "Input Roll";
     if ch = 2 then print "Jam";
     print " downtime total > "; dntime(ch);
     wait 500
     goto 4190

4100 ' Maintenance downtime selected
     maintmd = 1
4190 return


4300 '*************************************************************
     ' Maintenance Downtime Accumulation.
     if maintmd = 0 then 4390            ' Exit if not in maintenance mode
     ch = 3                              ' Select maintenance downtime
     gosub 4400                          ' Update downtime array
     maintmd = 0
4390 return


4400 '*************************************************************
     ' Get current time and calculate downtime, then add to selected
     ' downtime array element.
     ' Input:
     '   ch = downtime array element to update (0-3)
     ' Output:
     '   dntime(ch) = updated
     '   ch is unmodified
     getime a,b,c
     a = a - dhour
     if a < 0 then a = a + 24
     b = b - dmin
     if b < 0 then b = b + 60
     c = c - dsec
     if c < 0 then c = c + 60
     a = a * 24 + b * 60 + C
     dntime(ch) = dntime(ch) + a
     totdntm = totdntm + a
     network 3,0,2,totdntm,st            ' Store total downtime in network var.

     return


5000 '*************************************************************
     ' Emergency Stop
     task 1
     t1tmp = din(IESTOP)
     if t1tmp = 0 then estopmd = 0: exit    ' EStop button not pressed
     if t1tmp = 1 and estopmd = 1 then exit ' Already in EStop mode

     ' Signal the rest of the program that EStop has occurred.
     estopmd = 1

     ' Force the main drive to stop.  This happens even if we don't
     ' think that it is currently running.
     dac 1,512                           ' Stop main drive
     wait 100                            ' Wait for it to stop
     dout OMDRV,0                        ' Disable main drive
     exit
```

```
6000 '****************************************************************
     ' Transfer Shift Data over Network
     task 2
     network 4,0,30,t2,t2st             ' Read the "end of shift" flag
     if t2 = 0 then 6390                ' If flag clear then exit

     ' Shift has ended, so copy data into network registers for PC to
     ' read.
     network 3,1,30,srolcnt,t2st
     srolcnt = 0.0                      ' Clear the roll count
     network 3,1,31,syards,t2st
     syards = 0                         ' Clear the yards count
     for t2 = 0 to 3
       network 3,0,32+t2,dntime(t2),t2st
       dntime(t2) = 0                   ' Clear the individual downtimes
     next t2

     ' Now set the flags so that the PC will read the new data.
     network 3,0,30,0,t2st              ' Clear the "end of shift" flag
     network 3,0,31,1,t2st              ' Set "data available" flag

     totdntm = 0                        ' Clear the downtime total
6390 exit


     '****************************************************************
     ' Need this TASK statement to prevent corruption of temporary variables.
     task 3

8000 '****************************************************************
     ' Get a key with timeout
     ' Output: ch, timeout
     timeout = 0
8010 if din($100) <> 0 then goto 8010
     wait 10
8020 if key <> 0 then goto 8020

8030 wait 10: ch = key
     if ch = 0 and timeout < delay then timeout = timeout + 1: goto 8030
     return


8100 '****************************************************************
     ' Display main screen
     ' Input:
     '   maintmd, prdnum, batnum$, prolcnt, brolcnt, rrolcnt, ydsleft
     '   lnsetp
     ' Modifies:
     '   ftemp
     erase
     print "Product# ";
     fprint "i4x4z",prdnum
     print "Batch# "; batnum$; "    ";
     if maintmd then print "Maint";
     locate 2,1
     print "Prod:";
     fprint "f5.0z",prolcnt
     print "   Batch:";
     fprint "f5.0z",brolcnt
     print "   Yds left:";
     a = ydsleft
     fprint "i4z",a
     return


8300 '****************************************************************
```

```
     ' Subroutine to get INTEGER user input.
     cls: print uifmt$; uivlu;: wait 30
8310 K = din ($100): if K=0 then 8310
     if K = $41 or K = 13 then K=key: K=0: return
     if K<$30 or K>$39 then K=key: goto 8310
     locate 1,len(uifmt$)+1: print "       ";
     locate 1,len(uifmt$)+1: finput uifmt2$, uivlu
     K=1: return


8400 '************************************************************
     ' Subroutine to get REAL user input.
     cls: print uifmt$;: fprint "F4.2z",uirvlu
     print "F8 is decimal point";: wait 30
8410 K = din ($100): if K=0 then 8410
     if K = $41 or K = 13 then K=key: K=0: return
     if K<$30 or K>$39 then K=key: goto 8410
     locate 1,len(uifmt$)+1: print "         ";
     locate 1,len(uifmt$)+1: finput uifmt2$, uirvlu
     K=1: return


8500 '************************************************************
     ' Subroutine to get boolean (0 or 1) user input.
     cls: print uifmt$; uivlu: print uifmt2$;: wait 30
8510 K = get
     if K = $41 or K = 13 then return
     if K <> $7F then 8530
     locate 1,len(uifmt$)+1: print "0      ";
     uivlu=0: goto 8510
8530 if K<$30 or K>$31 then 8510
     locate 1,len(uifmt$)+1: print chr$(K); "      ";
     uivlu=K-$30
     goto 8510

8600 '************************************************************
     ' Subroutine to get string user input.
     cls: print uifmt$; uisvlu$;: wait 30
8610 K = din ($100): if K=0 then 8610
     if K = $41 or K = 13 then K=key: K=0: return
8620 locate 1,len(uifmt$)+1: print "                          ";
     locate 1,len(uifmt$)+1
     a = 0
     uisvlu$ = ""
8630 K = get
     if K = 8 then 8620
     if K = 13 then 8690
     uisvlu$ = concat$(uisvlu$,chr$(K))
     print chr$(K);
     a = a + 1
     if a < uilen then 8630
8690 K=1: return
```

4.3.4 Program Operating Instructions

The program has been designed to run on the Divelbiss Boss Bear Demonstration Case; the I/O numbers were chosen to match the wiring of this case. In order to run the program without a Demo Case, the following I/O devices must be supplied by the user:

Run pushbutton	input 1
Switch to simulate optical sensor	input 2

Emergency stop switch	input 3
Knife output	output 1
Conveyor gate open	output 2
Core hopper gate open	output 3
Main drive enable to turn on motor controller	output 7
Main drive speed select	DAC channel 1
Product length encoder	counter 1

The main drive motor must be coupled to the product length shaft encoder in order for the program to operator correctly, because the program uses the shaft encoder value to control the motor speed.

Before running the example program, EEPROM location 1 must be set to the Boss Bear unit number, so that the network works correctly. This is done by writing a short program to POKE the correct value into location 1. For example, if there is only one Boss Bear wired up to the network, the run the program `100 EEPOKE 1,1` (only one line).

Download the program into the Boss Bear and RUN it. The main screen will be displayed:

```
Product# 1002    Batch# 963895
Prod:    0   Batch:    0   Yds left:8532
```

If no action is taken for 60 seconds (no keypad buttons pressed, Run button not pressed, and Emergency Stop button not pressed), then the downtime screen will be displayed:

```
F1-Break    F2-Input Roll    F3-Jam
F4-Maintenance
```

Press F1, F2, or F3 to enter a downtime code; the number of seconds attributed to that downtime code thus far in the shift will be displayed. Press F4 to enter maintenance mode; the main screen will be redisplayed with "Maint" showing in the top right corner; the system may be run, but any rolls produced will not count towards production totals. When in maintenance mode, press F2 from the main screen to exit maintenance mode.

While in the main screen, press F1 to enter the "Operator Data Entry" state. It will ask for the batch number, product number, input roll length, and operator number. Enter a six digit number for the batch number; the function keys will enter the characters A through F. For the product number, it will only accept the numbers 1000, 1001, 1002, and 1003; these are the only numbers in the program DATA statements. Enter a number between 1 and 9999 for the input roll length. Enter a number between 0 and 9999 for the operator number. If the existing value of any parameter is still acceptable, then just press ENTER to leave the existing value in place.

Make sure that the optical sensor switch is on and press the run pushbutton to start a product roll. The motor speed will ramp up to a constant speed, hold that speed for a few seconds, then ramp down and stop. The knife output will turn on for 1/5 second, then the conveyor gate output will turn on. Turn off the optical sensor switch. The conveyor gate output will turn back off, and the core hopper gate output will turn on. Turn on the optical

sensor switch; the core hopper gate output will turn back off. The production totals on the main screen display will be updated. Press the run pushbutton to do this all again.

Chapter 5
Multitasking in Bear BASIC

Many control problems can be separated into a small number of tasks that are mostly independent of each other, yet must be performed at the same time. Traditionally, these control systems have been constructed using several independent process controllers; for example, a system may have two temperature controllers, a motor speed controller, a flow controller, an operator's panel, and a general purpose programmable controller to interface all of the others. Each of these controllers handles its own small part of the system, which allows each part of the system to be easily understood.

When a system such as this is implemented on a single controller, however, it can quickly become extremely complex, because the controller must be programmed to perform all of the tasks concurrently. For example, while it is waiting for the operator to enter a number on the keypad, it must still be controlling the motor speed, process temperature, etc. It becomes especially difficult to modify the operation of the system, such as adding another controller or changing the update rate of one of the existing controllers. What is needed is some way to make the single controller act like multiple, individual control modules.

The Bear BASIC compiler supports multitasking, which is a powerful programming tool that allows portions of a program to execute concurrently. The Boss Bear switches rapidly between different portions of the program, called tasks, giving the illusion that each task is being executed on it's own processor. If each of the controllers in the above example were implemented as separate tasks, then it would be similar to building the system out of individual controllers, making the software simpler to write and easier to modify in the future. This chapter explains how multitasking works, how to decide when it should be used, and how to use it correctly.

5.1 Multitasking Fundamentals

A Bear BASIC program may be divided into portions, called tasks, which can be thought of as independent programs which execute concurrently. Bear BASIC contains a piece of software called the **context switcher**, which manages all of the multitasking operations. Every 10 milliseconds (ie. 100 times per second), the Boss Bear suspends normal program execution and jumps to the context switcher (this is handled through the processor's internal TIMER0 interrupt, for those interested in the technical details). The context switcher updates its timing information, performs some system housekeeping (reads the keypad, handles the network, etc.), and then starts a task executing. The task that is started could be the one that was just interrupted, one that was interrupted at some earlier time, or one that had been waiting for an event to occur. Each 10 millisecond time interval is referred to as a **tick** in Bear BASIC. This is known as preemptive scheduling, since a task is preempted so that another task can execute.

All Bear BASIC programs consist of the main program, which is also known as the lead task or task 0. In order to form a multitasking program, one or more tasks must be created using the TASK statement, and task execution must be started with the RUN statement. The context switcher then causes the processor to be split among the executing tasks. Tasks are executed asynchronously with respect to each other; this means that it is impossible to predict exactly when a task will be interrupted so that another task can be run. It is possible for the programmer to synchronize the task execution, if necessary, by

using variables as semaphores (this will be discussed later). A simple example will show the basic operation of multitasking.

```
100  RUN 1                          ' Start task 1 executing
110  PRINT "|";                     ' Task 0 prints vertical bars
120  GOTO 110                       ' Loop forever
200  TASK 1                         ' Declare following code to be task 1
210  PRINT "_";                     ' Task 1 prints underscores
220  GOTO 210                       ' Loop forever
```

When this program is executed, it will alternate between printing "|" characters and printing "_" characters. Since each character will take about 1 millisecond to transmit at 9600 baud, it should print about 10 characters in each group, since each tick is 10 milliseconds long. Here is the output produced on one sample run:

```
||||||_________||||||||||_________||||||||||_________||||||||_________||||||||||_________
```

As far as each task is concerned, it gets to run all of the time; the context switcher takes care of switching between the tasks without any special BASIC code in the tasks. The RUN statement in line 100 is necessary to execute task 1.

Note that tasks are much different than subroutines. A subroutine is just a method of sharing a piece of code; it only executes when it is called with a GOSUB and it returns to the line following the GOSUB. A task, on the other hand, shares the processor with other tasks, appearing to execute at the same time as the other tasks. Tasks can be thought of as separate programs executing on the same processor. Bear BASIC supports 32 tasks, numbered 0 to 31. Since task 0 is always present, the first user task is number 1. Tasks must be numbered sequentially, starting with 1; an error will be generated if a TASK statement is found out of order.

5.1.1 RUN and EXIT Statements

The example above shows the simplest situation, in which two tasks run continuously, each getting about 50 percent of the processor's time. In many cases, the programmer needs more control of the task execution; the RUN, EXIT, WAIT, CANCEL, and PRIORITY statements provide this control by causing task execution to be started, stopped, and postponed. The following example is a modification of the previous example; it shows the use of the RUN and EXIT statements.

```
100  RUN 1,2                        ' Start task 1 executing, resched = 2
110  PRINT "|";                     ' Task 0 prints vertical bars
120  GOTO 110                       ' Loop forever
200  TASK 1                         ' Declare following code to be task 1
210  PRINT "_";                     ' Task 1 prints an underscore
220  EXIT
```

The RUN statement in line 100 starts task 1 executing with a reschedule interval of 2. This means that when task 1 executes an EXIT statement, it will be rescheduled to begin execution again in 2 ticks. Since task 1 just prints a single character, it is finished in about 1 millisecond. When it executes the EXIT statement in line 220, task 1 is stopped and scheduled to start again in 2 ticks. The context switcher lets task 0 run for the rest of the tick (approximately 9 milliseconds). At the next tick, task 0 gets to continue executing

because task 1 is still waiting for the second tick of its 2 tick reschedule period. At the next tick, task 1 gets to execute, starting the process over again. The output from this program should be a series of about 19 vertical bars (in the 19 milliseconds that task 0 executes) followed by an underscore, repeated over and over. Here is a sample of the output:

5.1.2 WAIT Statement

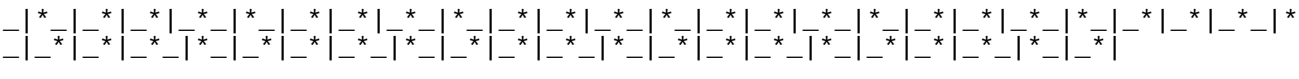
When it is necessary for a task to delay processing for a given time period, the WAIT statement is used. WAIT causes the task to suspend processing for the specified number of ticks; for example, WAIT 100 will delay for 1 second, since each tick is 1/100 second. While this task is suspended, other tasks continue to execute. When the context switcher executes at the beginning of each tick, it decrements the "wait counter" for any task that has executed a WAIT statement. When a task's counter reaches 0, that task is considered to be ready to run, and re-enters the normal scheduling system; this does not necessarily mean that this task will be the next one to be executed, unless it has the highest priority. If all of the tasks are waiting at the same time, then the context switcher just kills time until one of them is ready to run; background interrupt processing continues during this period. The WAIT statement is useful in non-multitasking programs, also, since it allows the programmer to easily delay for a fixed time period.

```
100  PRINT "*";
110  WAIT 100
120  GOTO 100
```

This example uses the WAIT statement to cause a 1 second delay in a program. It will print a "*" character each second until the program is stopped by pressing CTRL-C. The next example shows a more complex use of the WAIT statement.

```
100  RUN 1,10                      ' Start task 1, resched = 0.1 sec
110  PRINT "_";
120  WAIT 20                       ' Print "_" every 0.2 second
130  GOTO 110
200  TASK 1
210  PRINT "|";
220  WAIT 15                       ' Delay for 0.15 second
230  PRINT "*";
240  EXIT                          ' Done. It will run again in 0.1 sec
```

This example uses WAIT in a multitasking program. Note that task 1 performs a WAIT between printing the "|" and "*" characters, and that there is another delay caused by the 0.1 second reschedule interval that occurs when the EXIT is executed. The following output is produced when this program is run:



5.1.3 CANCEL Statement

In most situations, a task doesn't need to execute all of the time; for example, a task may only need to execute when the machine is moving. The CANCEL statement stops the rescheduling of a task. It does not halt the execution of the task at it's current location; instead, it prevents it from being started again after it executes the next EXIT statement. A task may CANCEL itself or any other task (except task 0, which always runs). The following example shows the use of the CANCEL statement:

```
100  INTEGER J
110  J=0
120  RUN 1,2                          ' Start task 1, resched = 0.02 sec
130  IF J=8 THEN CANCEL 1: GOTO 150 ' Wait for task 1 to count to 8
135  PRINT "*";                       ' Print "*"s while waiting
140  GOTO 130
150  WAIT 200                         ' Delay to allow task 1 to finish
160  PRINT "Done"
170  STOP
200  TASK 1
210  J=J+1                            ' Increment counter variable
220  PRINT J
230  EXIT
```

Line 120 starts task 1 executing with a reschedule interval of 2 ticks (2/100 second). Line 130 checks to see if J, which is being incremented by task 1, has reached 8 yet; if it has, then task 1 is CANCELed and the program jumps to line 150. If J hasn't reached 8 yet, then it just prints "*" characters and continues waiting. Since the CANCEL statement only prohibits the task from being rescheduled, the task must execute one more time after the CANCEL statement is executed. Line 150 waits for 2 seconds to allow task 1 to finish executing; this could be a much shorter delay, since task 1 will run again after 2 ticks. The following output is produced when this program is run:

```
******1
****************2
****************3
****************4
****************5
*****************6
****************7
****************8
9
Done
```

This example demonstrates one of the most important points about canceling a task: the task will execute one more time after the CANCEL statement is executed. This is because CANCEL sets a flag which tells the context switcher to not reschedule the task when it next executes an EXIT statement.

This example also shows an important point about task timing: below a certain resolution, it is unpredictable. In the sixth line of the output, an extra '*' character is printed, because of slight timing variations in the program execution and the serial port. This point will be brought up several times, as it is extremely important.

5.1.4 PRIORITY Statement

Sometimes, one task needs to exclude the other tasks from executing. For example, a task may be performing a time-critical section of code, and needs to guarantee that the context switcher won't switch to other tasks in the middle of this code, causing an unacceptable delay. The PRIORITY statement provides a solution to this problem. When the context switcher is choosing the next task to execute, it will execute the highest priority task that is ready to run. The task that has the highest priority will continue to execute until it hits a WAIT statement or an EXIT statement, or until it resets its priority level low enough to allow another task to run. If the highest priority task doesn't WAIT, EXIT, or reset its priority, then no other task will get a chance to execute. The priority level of each task is set to 0 when the program begins executing, causing the tasks to be executed in a round robin manner until PRIORITY statements are used to set higher priorities. The priority level ranges from 0 through 127, with a higher number indicating higher priority.

```
100  ' PRIORITY statement example
110  INTEGER J,K
150  RUN 1: RUN 2,1                 ' Start tasks running
190  J=0                            ' Initialize counter variable
200  PRINT "0";
205  FOR K=1 TO 52: NEXT K          ' Delay for awhile
210  J=J+1: IF J=15 THEN PRIORITY 1 ' Bump the priority up
220  IF J=38 THEN PRIORITY 0: J=0: PRINT  ' Reset priority to 0
230  GOTO 200
300  TASK 1
310  PRINT "1";
315  WAIT 1
320  GOTO 310                       ' Task 1 is an infinite loop
400  TASK 2
410  PRINT "2";
420  EXIT                           ' Task 2 gets rescheduled
```

This example uses the PRIORITY statement to cause task 0 to lock out tasks 1 and 2 periodically. After task 0 has printed 15 "0"s, it sets its priority up to 1 in line 210, making it the highest priority task. After it has printed 38 "0"s, it resets its priority to 0, allowing tasks 1 and 2 to execute again. Following is a sample of the output:

```
00120000012000001200000000000000000000000000
01200000120000012000000000000000000000000000
00000120000012000001200000000000000000000000
00001200000120000012000000000000000000000000
00012000012000001200000000000000000000000000
01200001200000120000012000000000000000000000
00001200000120000012000000000000000000000000
00012000001200000120000000000000000000000000
00120000120000012000000000000000000000000000
01200001200000120000012000000000000000000000
00012000001200000120000000000000000000000000
```

5.2 Determining Task Timing

When the operation of the context switcher is viewed over a sufficiently long period of time, it gives the illusion that multiple tasks are running concurrently. As shown in the previous examples, however, when the operation is viewed over a smaller period of time, it is evident that the processor is switching rapidly between tasks. In some situations, the context switcher's operation must be considered carefully while programming.

It can be very difficult to predict how the context switcher is going to execute the tasks. In fact, it is impossible to predict exactly what the context switcher is going to do, since there is no way to predict exactly where the program will be when the tick occurs. For example, if a program only has one task currently executing, and that task executes a WAIT 1 statement, then the delay will be between 200 µsec and 10 msec. If the tick occurs immediately after the WAIT statement is executed, then the task will continue executing after a 200 to 1000 µsec delay (the amount of time required for the context switcher to process everything and restart the task). If the WAIT statement is executed immediately after a tick has occurred, then it will be 10 msec until the next tick causes the task to be restarted.

The situation is even more complex if multiple tasks are currently executing, since one or more tasks may get to execute before a task that has executed a WAIT statement. For example, in a program with three tasks that are all at priority level 0 (the default level), suppose that task 1 executes a WAIT 10 statement. After 10 ticks in which tasks 0 and 2 continue to execute, task 1 is ready to run again. However, being ready to run does not mean that the task will run immediately, only that it will be run the next time that the context switcher gets to it. This means that it could execute both task 0 and 2 before it gets to task 1, causing the total time delay for the WAIT 10 statement to be 12 ticks. If task 1 were executing at a higher priority than tasks 0 and 2, however, then it would have executed before them, causing the delay to be 10 ticks.

The result of this is that the BASIC programmer shouldn't rely on the context switcher to provide accurate timing at the millisecond level. The Boss Bear is capable of performing operations with a timing accuracy of 1 msec, if necessary, using the timer interrupt. Also, the programmer can modify the task priorities to ensure that time critical sections of code get executed without interruptions from other tasks. If a section of code is extremely time critical (for example, two outputs must be turned on within microseconds of each other), then the INTON and INTOFF statements can be used to ensure that the code gets executed without any interruptions (including hardware interrupts).

5.3 Determining When and How to use Multitasking

In many cases, multitasking techniques can make a program much simpler to write and understand. It is not the proper choice for all programs, however. If a multitasking approach is attempted in a situation which is not well suited to it, the resulting program could be quite difficult to understand and debug. Programming experience is highly desirable in order to determine whether a multitasking approach should be used. The following guidelines can be used as a starting point when making this determination.

Fundamentally, multitasking should be used when a system consists of parallel subsystems; each subsystem can be programmed as a separate task. An example would be a control program that implements a temperature control and a speed control; each controller would be a separate task. Multitasking should not be used with systems that are primarily sequential; these should be handled as regular sequential BASIC code. For example, a system that picks up a part, moves it into position, drills a hole, and then drops it onto a conveyor, consists of a sequence of actions that must be performed in order;

attempting to write this as a multitasking program would be a major mistake. In practice, most systems consist of both sequential and parallel components; multitasking should be used when the parallel components are large and relatively independent of each other.

Another primary consideration is program speed. The overhead imposed by the context switcher increases as the number of tasks increases. In some high speed applications it is necessary to avoid multitasking in order to get the greatest speed. To get the maximum performance from the Boss Bear, the program should be implemented using a combination of assembly language and C; Divelbiss offers a C compiler and an assembler for the Boss Bear.

A program's user interface is often difficult to implement, especially if the control system must continue to run while the operator is pressing keys. This is a situation where multitasking can make the program much simpler, since one task can handle the user interface while other tasks continue to control the system. In general, the program will be easier to write and debug if all user I/O to a particular file is contained in a single task. For instance, if two tasks could be accessing the display concurrently, then the program will have to ensure that they don't corrupt each others information; it doesn't do much good to display an alarm, only to have another task clear the display an instant later.

5.4 Interaction Between Tasks

Each task will be performing an independent function in a well-organized program. In most cases, though, some of the tasks will need to pass information to other tasks. An example would be a system where a bar code reader task would need to change the setpoint values being used by box folding task (when it detects different products coming in on a conveyor, for instance). A multitasking program will be easier to implement if the interaction between tasks can be minimized. In most programs, the tasks will have to interact somewhat, however. This can lead to some problems which the programmer needs to watch for. Several techniques are given here that allow reliable communication between tasks.

Computer systems usually include items that are limited to a small number of units; these items are referred to as "scarce resources". For example, a mainframe computer system may have three identical line printers attached, allowing three print jobs to execute concurrently; any new print requests must wait until one of the first three finishes. The printers are a scarce resource. Software can also be a scarce resource; a subroutine can usually only be called from one task at a time, making that subroutine a scarce resource. In a multitasking system, the software must manage the scarce resources so that too many tasks don't try to use a resource concurrently. This is another form of task interaction that the programmer must be aware of.

The programmer must be careful when tasks interact, because there is no way to predict when the context switcher will switch between tasks. This means that one task may be in the middle of updating a variable when another task gets to execute; if the second task uses the same variable, then unpredictable operation could result. The following example demonstrates this:

```
100  INTEGER J, K
```

```
140  J=0
150  RUN 1,10
210  K=J
220  IF K <> J THEN PRINT "Error": STOP
240  GOTO 200
500  TASK 1
510  J=J+1
520  PRINT "*";
530  EXIT
```

If the context switcher interrupts task 0 after line 200 or while it is evaluating line 210, then task 1 will modify the value of J. This will cause the test in line 210 to fail when task 0 gets to execute again. A simple solution to this particular problem involves using the PRIORITY statement to control access to the variable J, as follows:

```
100  INTEGER J, K
140  J=0
150  RUN 1,10
200  PRIORITY 1                    ' Lock out task 1
210  K=J
220  IF K <> J THEN PRINT "Error": STOP
230  PRIORITY 0                    ' Allow task 1 to execute again
240  GOTO 200
500  TASK 1
510  J=J+1
520  PRINT "*";
530  EXIT
```

Once task 0 sets its priority to 1 in line 200, task 1 can't execute again until task 0 sets its priority back to 0 in line 230. A side effect of this is that task 1 executes less often, because task 0 is spending most of the time at priority 1. If this is a problem, then a WAIT 1 statement could be inserted at line 235 to allow task 1 time to execute. A more serious problem with this approach is that it only protects task 0 from task 1; it doesn't protect task 1 from task 0 (ie. task 0 can interrupt task 1 and could modify values being used by task 1). A solution to this problem involves using variables as flags to protect critical regions of code; these are normally called semaphores in computer literature.

```
100  ' Example to demonstrate the use of semaphores to protect a region of
102  ' code from other tasks.  Task 0 and task 1 are both displaying numbers
104  ' on the terminal using the LOCATE and PRINT statements.  The code must
106  ' ensure that one task can't write to the display in between the other
108  ' task's LOCATE and PRINT, thereby corrupting the display.  The display
110  ' is the scarce resource in this example; it can only be used by one task
112  ' at a time (without displaying values at the wrong locations.
120  INTEGER COUNT1, COUNT2         ' Counter variables
130  INTEGER SEM1                   ' Semaphore flag
140  INTEGER LOOP1, LOOP2           ' Loop counters
200  SEM1=0                         ' Initialize semaphore to 0
210  ERASE
220  COUNT1=0: COUNT2=COUNT1        ' Initialize task counters to 0
230  RUN 1
300  ' Task 0 main loop.
310  COUNT1=COUNT1+1
315  ' Next two lines perform critical region protection, to lock the
316  ' console display.
320  INTOFF: IF SEM1 < 0 THEN INTON: WAIT 1: GOTO 320
330  SEM1=SEM1-1: INTON
340  LOCATE 10,10: PRINT COUNT1;    ' Display current count
350  INTOFF: SEM1=SEM1+1: INTON     ' Unlock the console display
360  FOR LOOP1=1 TO 500: NEXT LOOP1 ' Simulate execution of other code
370  GOTO 300
```

```
400  TASK 1
410  COUNT2=COUNT2+1
415  ' Next two lines perform critical region protection, to lock the
416  ' console display.
420  INTOFF: IF SEM1 < 0 THEN INTON: WAIT 1: GOTO 420
430  SEM1=SEM1-1: INTON
440  LOCATE 20,10: PRINT COUNT2;    ' Display current count
450  INTOFF: SEM1=SEM1+1: INTON     ' Unlock the console display
460  FOR LOOP2=1 TO 900: NEXT LOOP2 ' Simulate execution of other code
470  GOTO 410
```

This program has two tasks that are writing to different locations on the terminal (attached to COM1); it uses a semaphore to control access to the COM1 port, so that one task doesn't print at the other task's screen location. In task 0, lines 320, 330, and 350 implement the semaphore locking algorithm. In line 320, it checks to see if COM1 is available (indicated by SEM1=0); if it isn't, then it waits 1 tick to allow the task that is using COM1 to finish, and loops back to check again. When COM1 is finally available (SEM1=0), then it decrements SEM1 (to -1) to indicate to other tasks that COM1 is in use. The interrupts must be turned off while accessing SEM1, so that two tasks don't access it at the same time, which could allow both tasks to access COM1 concurrently. When the task is finished with COM1, it unlocks it by incrementing SEM1 in line 350, allowing another waiting task to continue when it sees SEM1=0. In task 1, lines 420, 430, and 450 perform the same locking function that lines 320, 330, and 350 do. This technique will work with any number of tasks by using these three lines around any critical code that must be protected.

5.5 Organization of Tasks and Subroutines

This section discusses the manner in which a multitasking program should be organized. It is extremely important that the tasks and subroutines are put in the proper locations; if they aren't, then the BASIC program will operate unpredictably. Incorrect organization of the program can cause some very subtle problems that can be quite difficult to find. Fortunately, the problem can be avoided in most cases by following a few simple rules.

Before getting into the details, a few comments must be made about tasks. Tasks must be declared in numerical order starting with number 1; also note that the code before the 'task 1' statement actually belongs to task 0. All of the code between two TASK statements is part of the same task, as far as the compiler is concerned; everything up to the 'task 1' statement is in task 0 and everything from the 'task 1' statement up to the 'task 2' statement is in task 1, for example.

In general, a Bear BASIC program must have its tasks declared at the end of the program, after the variable declarations and mainline code; this includes any tasks that are handling hardware interrupts (ie. referred to in a VECTOR statement). The following example illustrates the proper form for a program; the program would contain code that has been left out for clarity, but all TASK and GOSUB statements are included here (there are no GOSUBs in this program). Note the test after line 300 ('if test <> 0 then ...'); this will never print because 'test' is always 0. The following example demonstrates the basic form that a Bear BASIC program should follow:

```
100   ' Variable declarations
      integer test
      integer x1, x2
200   ' Start of program code.  This is task 0.
      run 1,10                      ' Run task 1 10 times/second
      run 2,5                       ' Run task 2 20 times/second
      test = 0                      ' Initialize test flag

      ' Mainline code loop
300   if test <> 0 then print "Failed mainline"
      goto 300

10000 task 1
      ' code for task 1
      x1 = x1 + 1
      exit

11000 task 2                        ' Last task in program
      ' code for task 2
      x2 = x2 + 1
      exit
```

The existence of subroutines in a program complicates matters. The simplest situation occurs when each subroutine is only called from within a single task. In this case, each subroutine should be within the boundaries of the task that calls it; for example, a subroutine that is called by task 4 must be between the 'task 4' and 'task 5' statements. Let's expand the preceding program to illustrate this point; again, even though a lot of code is missing from this example, all of the TASK and GOSUB statements are shown here. The important point in this example is that the subroutine at 1000 (which is in task 0) is only called from within task 0, and the subroutine at 10200 (which is in task 1) is only called from task 1. The 'test' variable is checked in each task; since it is always 0, no messages will be printed.

```
100   ' Variable declarations
      integer test
      integer x0, x1, x2
200   ' Start of program code.  This is task 0.
      run 1,10                      ' Run task 1 10 times/second
      run 2,5                       ' Run task 2 20 times/second
      test = 0

      ' Mainline code loop
300   if test <> 0 then print "Failed mainline"
      gosub 1000
      goto 300

1000  ' Subroutine called only by task 0 (mainline)
      ' Code for subroutine goes here
      x0 = x0 + 1
      return

10000 task 1
      ' Code for task 1
      gosub 10200
      x1 = x1 + 1
      if test <> 0 then print "Failed task 1"
      exit

10200 ' Subroutine called only by task 1
      ' Code for subroutine goes here
      ' This is still part of task 1
      return
```

```
11000 task 2                          ' Last task in program
      ' Code for task 2
      x2 = x2 + 1
      if test <> 0 then print "Failed task 2"
      exit
```

If the two rules outlined above are followed then your program will work as expected. Once again, the rules are:

1. All tasks must be at the end of the program.
2. Never call a subroutine that is outside of the task that contains the GOSUB to that subroutine.

Unfortunately, the second rule is quite limiting, because it means that multiple tasks can't call a common subroutine. In order to arrive at a solution to this problem, you must understand how the compiler works and why the above rules are necessary.

The situation comes about because of the method that the Bear BASIC compiler uses to allocate memory for a program. As each BASIC statement is executed, there are temporary values that are calculated and stored in a set of temporary variables; these values are only needed during the execution of a single statement. Each task has its own set of temporary variables; every statement within a task uses the same set of temporary variables, which is the cause of the difficulty. Let's assume that a statement is being executed when the timer tick occurs; one or more tasks will execute before that statement gets to complete. If any one of those tasks is using the same temporary variables as the statement, then when it finally gets to complete execution, its temporary values will have been altered, resulting in incorrect operation of the program. How could one of the intervening tasks use the same temporary variables as the original statement? The simplest situation would be if one of the intervening tasks called a subroutine that was in the same task as the statement that was interrupted. Here are two examples that illustrate a few ways that this could happen:

```
10    ' This example contains a task that calls a subroutine that is
      ' located within another task (task 1 calls the subroutine at 1000,
      ' which is in task 0).  If task 0 is executing the statement in
      ' line 300 when the timer tick occurs, allowing task 1 to run, then
      ' when task 0 finishes executing line 300, an erroneous conclusion
      ' will be reached.  When task 1 calls 1000, it will have altered the
      ' temporary variables being used in line 300, because 300 and 1000
      ' both use the same temporary variables.

100   ' Variable declarations
      integer test
      integer x0, x1, x2
200   ' Start of program code.  This is task 0.
      run 1,10                        ' Run task 1 10 times/second
      run 2,5                         ' Run task 2 20 times/second
      test = 0

      ' Mainline code loop.  Line 300 will sometimes operate
      ' incorrectly, printing the message even though "test" is 0.
300   if test <> 0 then print "Failed mainline"
      gosub 1000
      goto 300

1000  ' Subroutine called from multiple tasks
      ' Code for subroutine goes here
      x0 = x0 + 1
      return
```

```
10000 task 1
      ' Code for task 1
      gosub 10200
      gosub 1000
      x1 = x1 + 1
      if test <> 0 then print "Failed task 1"
      exit

10200 ' Subroutine called only by task 1
      ' Code for subroutine goes here
      ' This is still part of task 1
      return

11000 task 2                        ' Last task in program
      ' Code for task 2
      x2 = x2 + 1
      if test <> 0 then print "Failed task 2"
      exit
```

Here is the second example:

```
10    ' This example breaks rule number 1 by putting the mainline code
      ' after task 2, which means that the mainline code will be using
      ' the same temporary variables as task 2.  When a timer tick causes
      ' task 2 to execute, it will modify its temporary variables and
      ' possibly cause an expression in the mainline to be evaluated
      ' incorrectly.  One possible solution to this would be to put a
      ' 'task 3' statement at line 20000; this would cause the compiler
      ' to use a new set of temporary variables for the mainline code.
100   ' Variable declarations
      integer test
      integer x0, x1, x2
200   ' Start of program code.  This is task 0.
      run 1,10                      ' Run task 1 10 times/second
      run 2,5                       ' Run task 2 20 times/second
      test = 0
      goto 20000                    ' Jump to mainline loop

1000  ' Subroutine called from mainline
      ' Code for subroutine goes here
      x0 = x0 + 1
      return

10000 task 1
      ' Code for task 1
      gosub 10200
      x1 = x1 + 1
      if test <> 0 then print "Failed task 1"
      exit

10200 ' Subroutine called only by task 1
      ' Code for subroutine goes here
      ' This is still part of task 1
      return

11000 task 2                        ' Last task in program
      ' Code for task 2
      x2 = x2 + 1
      if test <> 0 then print "Failed task 2"
      exit

      ' Mainline code loop.  This is still part of task 2. Line
      ' 20000 will sometimes operate incorrectly, printing the
      ' message even though 'test' is 0.
20000 if test <> 0 then print "Failed mainline"
      gosub 1000
      goto 20000
```

So, is there a solution to the difficulties produced by rule number 2 above? Yes, it is possible to call a subroutine that is located in a different task, which means that it is possible to have a common subroutine that is called from multiple tasks. In order for it to work correctly, you must be able to guarantee that the subroutine can't interrupt any other code that is in the task that the subroutine is in. The simplest way to do this is to put the subroutine in a separate task and disable interrupts at the beginning and end of the subroutine. Of course, since the interrupts are disabled, the subroutine must be short and fast so that no hardware interrupts are lost. Multiple subroutines can be put into the same task, but they must all have interrupts disabled while executing. Remember that some BASIC statements and functions can't be used while interrupts are disabled, because they turn the interrupts back on prematurely; these include PRINT, INPUT, GET, string operations, and user defined functions. If a subroutine must use one of these and also be called from multiple tasks, then the subroutine should be placed in a task by itself. The following example illustrates these techniques.

```
100   ' Variable declarations
      integer test
      integer x0, x1, x2

200   ' Start of program code.  This is task 0.
      run 1,10                      ' Run task 1 10 times/second
      run 2,5                       ' Run task 2 20 times/second
      test = 0

      ' Mainline code loop.
300   if test <> 0 then print "Failed mainline"
      gosub 20000                   ' Subroutine called from multiple tasks
      gosub 21000                   ' Also called from multiple tasks
      goto 300

10000 task 1
      ' Code for task 1
      gosub 10200                   ' Only called from task 1
      gosub 20000                   ' Called from multiple tasks
      x1 = x1 + 1
      if band (x1, $7F) = 0 then gosub 22000
      if test <> 0 then print "Failed task 1"
      exit

10200 ' Subroutine called only by task 1
      ' Code for subroutine goes here
      ' This is still part of task 1
      return

11000 task 2                        ' Last task in program
      ' Code for task 2
11010 x2 = x2 + 1
      if band (x2, $7F) = 0 then gosub 22000
      gosub 21000
      if test <> 0 then print "Failed task 2"
      goto 11010

      ' The next task statement is used to separate the subroutines
      ' from the rest of the code; everything after the "task 3"
      ' statement will use the same set of temporary variables.
      ' Since the subroutines disable interrupts while executing,
      ' they can be called from multiple tasks without any problems.
      task 3
```

```
20000 ' Subroutine called from multiple tasks
      intoff
      ' Code for subroutine goes here
      x0 = x0 + 1
      inton
      return

21000 ' Subroutine called from multiple tasks
      intoff
      x0 = x0 - 1
      inton
      return

      task 4
22000 ' Subroutine called from multiple tasks.  This routine uses
      ' the PRINT statement, so it can't turn interrupts off.  This
      ' means that it must be put into a task by itself, so that it
      ' doesn't share temporary variables with any other routine.
      print "x0 = "; x0
      return
```

So, we can add a third rule to the list:

1. All tasks must be at the end of the program.
2. Never call a subroutine that is outside of the task that contains the GOSUB to that subroutine.
3. If the program contains subroutines that must be called from multiple tasks, then put all of these subroutines into a separate task, and disable interrupts during the subroutine execution. The subroutines must be short, and they can't use any of the PRINT, GET, or INPUT statements.

If subroutines can't disable interrupts while executing (because they are too long or execute statements that enable interrupts) then the subroutines should be treated as a scarce resource and protected with a semaphore. This technique is described in section 5.4 above. The subroutines are placed in a separate task, and then all accesses to any subroutine in that task must be protected with a semaphore flag. This will prevent multiple tasks from executing subroutines simultaneously, thereby preventing the subroutine temporary variables from being corrupted.

Chapter 6
User Interface Support

From an industrial control standpoint, one of the most attractive Boss Bear features is the availability of an onboard display and keypad. The user interface is an important part of many control systems, supplying the operator with important run time production information, and allowing him to make control parameter changes.

6.1 Using the Built-In Display

The Boss Bear is available with three types of onboard display:

2 row by 40 character Liquid Crystal Display (LCD)
2 row by 40 character Backlit LCD
2 row by 40 character Vacuum Fluorescent Display (VFD)

The main difference between the three display types lies in cost and readability. The VFD is the most readable under varying lighting conditions, and also the most expensive. The LCD is least expensive, and can be difficult to read in low ambient lighting conditions. The backlit LCD is easier to read in low light. Since all three displays are the same size, they can be interchanged without affecting the Bear BASIC program. LCD contrast is controlled by:

Clear & F1 - Increase
Clear & F2 - Decrease

The display is accessed as FILE 6. Any of the file output statements can be used: CLS, ERASE, FPRINT, GOTOXY, LOCATE, and PRINT. Each task maintains its own cursor position, so multiple tasks can write to the display concurrently without corrupting each other's information. The following example demonstrates the use of the display. It starts by scrolling a message onto the top line of the display, then it displays a counter value and the time of day on the second line.

```
100  INTEGER J,H,M,S
110  STRING A$(50)
200  A$="Divelbiss Boss Bear Controller     "
210  FILE 6                          ' Set task 0 to onboard display
220  CLS                             ' Clear the display
290  ' Scroll a message onto the display
300  FOR J=1 TO LEN(A$)
310  LOCATE 1,41 - J                 ' Position the cursor
320  PRINT MID$(A$,1,J)
330  WAIT 10
340  NEXT J
350  LOCATE 2,1: PRINT "Count:";
360  LOCATE 2,20: PRINT "Time:";
370  RUN 1,100                       ' Start task 1, reschedule once/second
380  J=0
390  LOCATE 2,8                      ' Position the cursor
400  FPRINT "U5Z",J                  ' Display current count value
410  WAIT 15: J=J + 1: GOTO 390      ' Update count and loop forever
500  TASK 1
510  FILE 6                          ' Set task 1 to onboard display
520  GETIME H,M,S                    ' Get time from real time clock
530  LOCATE 2,26                     ' Position the cursor
540  PRINT H;":";                    ' Print hour followed by colon
550  IF M < 10 THEN  PRINT "0";      ' Print leading zero if necessary
560  PRINT M;":";                    ' Print minute followed by colon
```

```
570  IF S < 10 THEN  PRINT "0";     ' Print leading zero if necessary
580  PRINT S;" ";                   ' Print second
590  EXIT                           ' Finished for now
```

The FILE 6 statements are necessary to cause the output to go to the onboard display; Bear BASIC will default to FILE 0, the console serial port. Each task must have its own FILE 6 statement, because each task maintains its own current file number.

When writing to the display in a multitasking program, it is important to avoid corrupting a portion of the display that another task may be using. In fact, it is often easier to handle all display operations in one task, just to simplify the program debugging.

The display is a relatively slow device, by computer standards. When a PRINT or FPRINT statement is executed, it is very likely that other tasks will get to execute before the statement returns.

6.2 Reading the Built-In Keypad

The keypad is composed of 20 keys (4 rows by 5 columns): 0-9, ENTER, CLEAR, and F1-F8. It is accessed as FILE 6. Any of the file input statements or functions can be used: FINPUT, GET, INPUT, INPUT$, and KEY. Figure 5 shows what values are returned for each key. The keypad is scanned continuously in the background; if a key press is detected, that key is inserted into an 8 key buffer. Each input operation returns the next character from this buffer.

The keypad should not be read from more than one task at the same time. Some of the key presses would go to one task and some would go to another, causing erroneous input. Multiple tasks can read the keypad, but not concurrently.

Keypad Overlay	GET/KEY Integer	INPUT String variable	INPUT Numeric variable
0	48	"0"	0
1	49	"1"	1
2	50	"2"	2
3	51	"3"	3
4	52	"4"	4
5	53	"5"	5
6	54	"6"	6
7	55	"7"	7
8	56	"8"	8
9	57	"9"	9
ENTER	13	CR/LF	CR/LF
CLEAR	8	Backspace	Backspace
F1	65	"A"	
F2	66	"B"	
F3	67	"C"	
F4	68	"D"	
F5	69	"E"	
F6	70	"F"	
F7	45	"-" minus sign	-
F8	46	"." decimal point	.

CR/LF indicates a carriage return, line feed pair.
Figure 5 – Keypad Return Values

The value returned by the keypad is dependent upon the operation being performed. The KEY and GET functions return an integer that corresponds to the key that was pressed. The INPUT and INPUT$ statements, when used with a string variable, return a text string; when used with a numeric variable, they return the number that the user typed in. The following example shows the values that are returned as keys are pressed.

```
100  INTEGER J,K
110  STRING A$(40)
120  FILE 6
130  ' Start by displaying GET values until ENTER is pressed
140  K=GET
150  LOCATE 1,1
160  PRINT K;" ";CHR$(K);
170  WAIT 100
180  IF K<>13 THEN 140
190  ' Now display INPUT with an integer variable
200  CLS: PRINT "Enter a number > ";
210  INPUT J
220  CLS: PRINT "The number was ";J
230  ' Now display INPUT with a string variable
240  PRINT "Enter anything > ";
250  INPUT A$
260  CLS: PRINT A$
270  ' Now show how FINPUT works
280  PRINT "Formatted input > ";
290  FINPUT "I4",J
300  CLS: PRINT "The number was ";J
```

Line 120 sets the current file to FILE 6, the onboard display and keypad. Lines 140 through 180 use the GET function to read the keypad; both the integer key value and the string equivalent are displayed. Because of the WAIT 100 in line 170, it is possible to type faster than keypresses are being read; the first eight keys are buffered, so none should be lost, however. When the ENTER key is pressed, the program continues to line 200, where it uses INPUT to get a numeric value from the user. Lines 230 through 260 demonstrate the INPUT statement with a string variable. Lines 270 through 300 use FINPUT to get a 4 character integer number.

6.3 Working With the Serial Ports

For applications which require a more complex user interface, a remote display, or remote data entry, a terminal may be attached to either serial port (**COM1** or **COM2**). If multiple data entry stations are required, terminals could even be installed on both serial ports. All of the file I/O statements and functions (see 7-13 for more information) work with the serial ports; **COM1** is FILE 0, and **COM2** is FILE 5. When a program starts executing, the default output device is FILE 0; each time that a task is RUN, that task's default device is FILE 0. Any of the file I/O statements and functions may be used to access the serial ports: CLS, ERASE, FPRINT, GOTOXY, LOCATE, PRINT, FINPUT, GET, INPUT, INPUT$, and KEY.

It is important to remember that the characters are displayed relatively slowly when using a terminal: 1 millisecond per character at 9600 baud. This means that a long PRINT statement may take 80 msec (or more) to complete. Device resource locking is performed on each I/O file individually. In a multitasking program, other tasks will continue to run while the PRINT statement is taking place, but no other task will be able to PRINT to the same port until the first PRINT finishes, however. Unfortunately, another task could change the cursor position of the terminal between PRINT statements. An example will demonstrate this problem and a simple solution.

```
100  INTEGER J: J=0
110  CLS
120  RUN 1,39: WAIT 30: RUN 2,60
130  J=J+1: WAIT 9: GOTO 130
200  TASK 1
220  LOCATE 10,10
230  FPRINT "S16U5Z", "Task 1 value is ", J
250  EXIT
300  TASK 2
320  LOCATE 15,40
330  FPRINT "S19U5Z", "Value in task 2 is ", J
350  EXIT
```

The desired result of this program is to display the count value (J) at two places on the screen using two tasks. When the program is run, however, it will periodically display one of the strings at the wrong location. This happens whenever the context switcher causes task 2 to execute immediately after task 1 has executed the LOCATE statement. Task 2 will perform another LOCATE, then print its message at the correct location. When task 1 runs again, though, it will print its message at the location following the message printed by task 2. This same situation will occur in the opposite order, causing task 2's message to be printed at the location following that of task 1's. The solution to this is to use a variable as a flag to prohibit another task from moving the cursor while a task is accessing the terminal.

The variable PF has been added to the example (see line 100); it will be nonzero when FILE 0 is in use. Lines 210, 215, 240, 310, 315, and 340 have been added to the previous example. When a task is ready to output to the terminal, it increments PF; interrupts must be disabled while updating PF (with INTOFF and INTON), to ensure that two tasks don't conflict. If PF is nonzero, then the other task is already using the terminal, so this task just waits and tries again later. When PF is zero, it indicates that the other task is finished, so this task continues.

```
100  INTEGER J,PF: J=0: PF=-1
110  CLS
120  RUN 1,39: WAIT 30: RUN 2,60
130  J=J+1: WAIT 9: GOTO 130
200  TASK 1
210  INTOFF: PF=PF+1: INTON          ' Update print flag
215  IF PF THEN WAIT 1: GOTO 215     ' Wait for other tasks to finish
220  LOCATE 10,10
230  FPRINT "S16U5Z", "Task 1 value is ", J
240  INTOFF: PF=PF-1: INTON          ' Finished with terminal, clear flag
250  EXIT
300  TASK 2
310  INTOFF: PF=PF+1: INTON          ' Update print flag
315  IF PF THEN WAIT 1: GOTO 315     ' Wait for other tasks to finish
320  LOCATE 15,40
330  FPRINT "S19U5Z", "Value in task 2 is ", J
340  INTOFF: PF=PF-1: INTON          ' Finished with terminal, clear flag
350  EXIT
```

Chapter 7
Onboard Hardware Support

One of the things which makes the Boss Bear such a cost effective control system is the hardware support which is available onboard the main system. Since real time control revolves around the ability to perform input and output with the real world, this is one of the most important chapters in the manual. This chapter, along with chapter 9, Optional Modules, describes the Boss Bear hardware that is available to the system designer.

Figure 6 and Figure 7 show the jumpers and connectors that are accessible from the Boss Bear's rear panel. Since this information is applicable to many of the sections in this chapter, it is presented first.

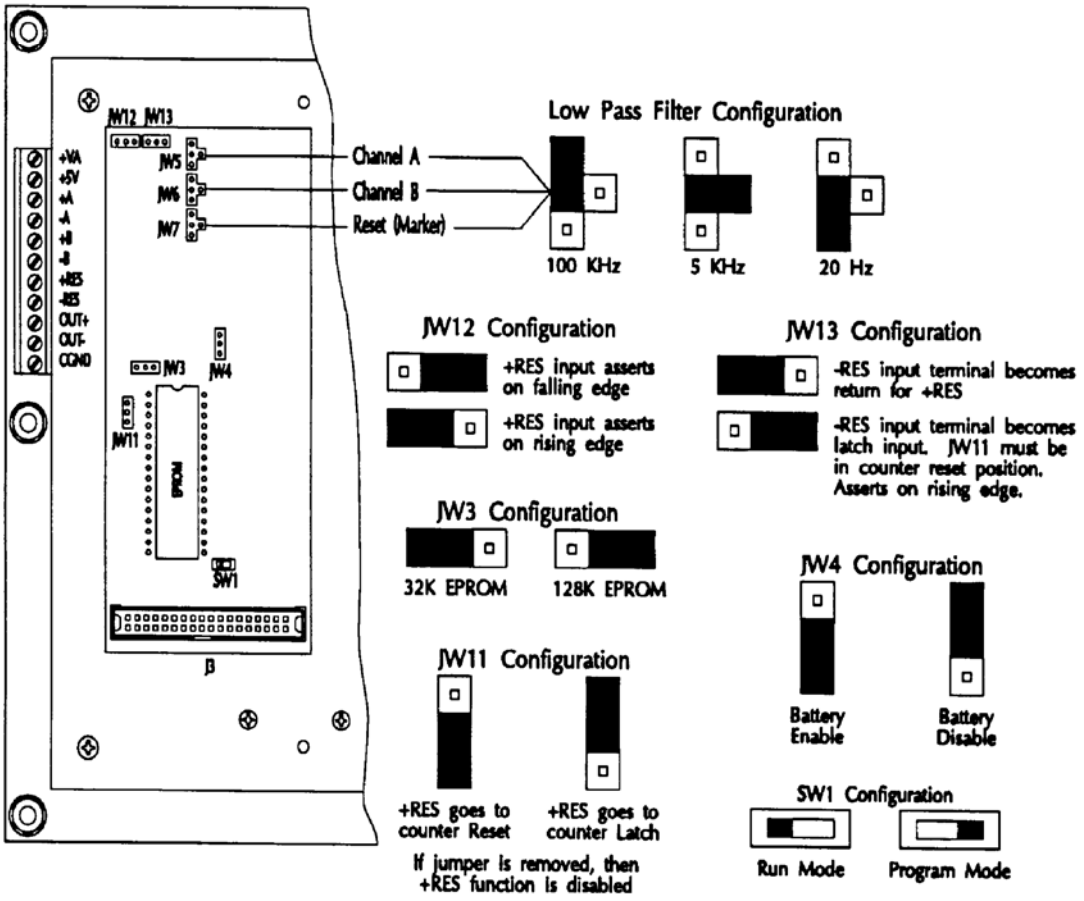


Figure 6 – Boss Bear Jumper Settings

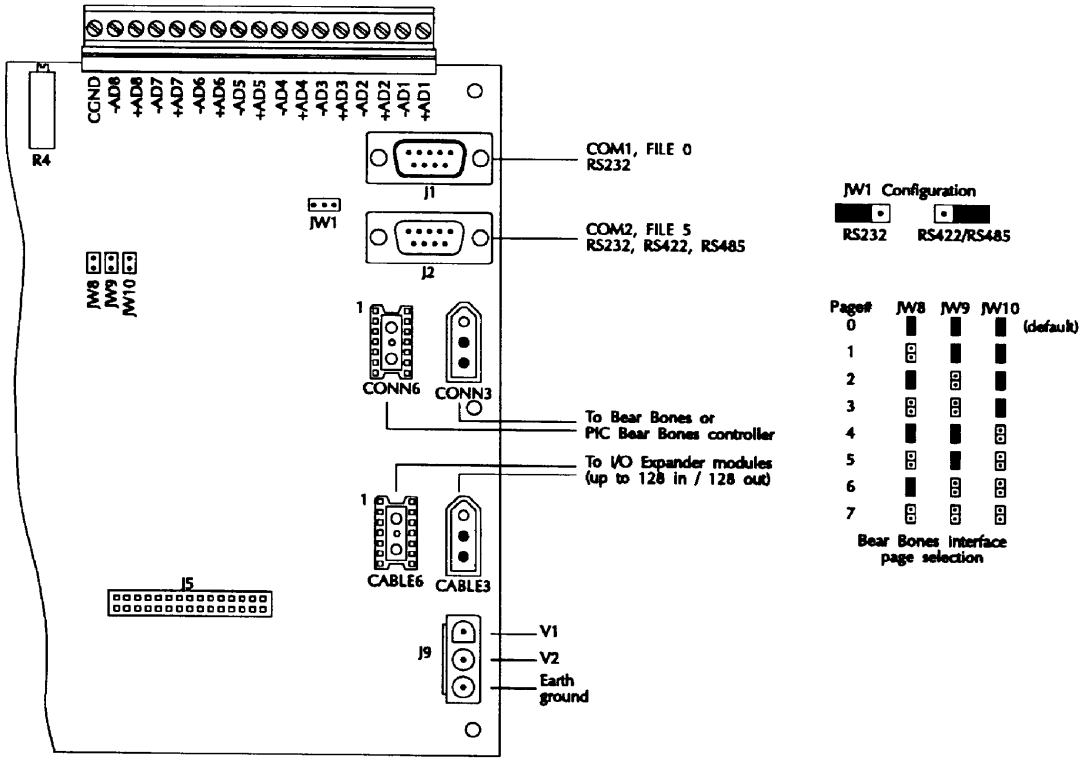


Figure 7 – Boss Bear I/O Connectors and Jumpers

7.1 High Speed Counter

Counting is a very common operation in real time control systems. For low speed signals (less than 10 pulses/second), this can be handled easily in software. At higher rates, however, hardware counters are required. The Boss Bear high speed counter circuit is very flexible, providing several operating modes. It is a 24 bit binary up/down counter, capable of greater than 1 MHz count rate (333 kHz in quadrature modes), with input filtering, and a high speed output. It supports quadrature mode, which allows it to operate with biphase shaft encoders. In order to understand the operation of the counter, it is helpful to look at the hardware logic. The onboard counter circuitry is very similar to the counter expansion module, so most of the following information applies to both.

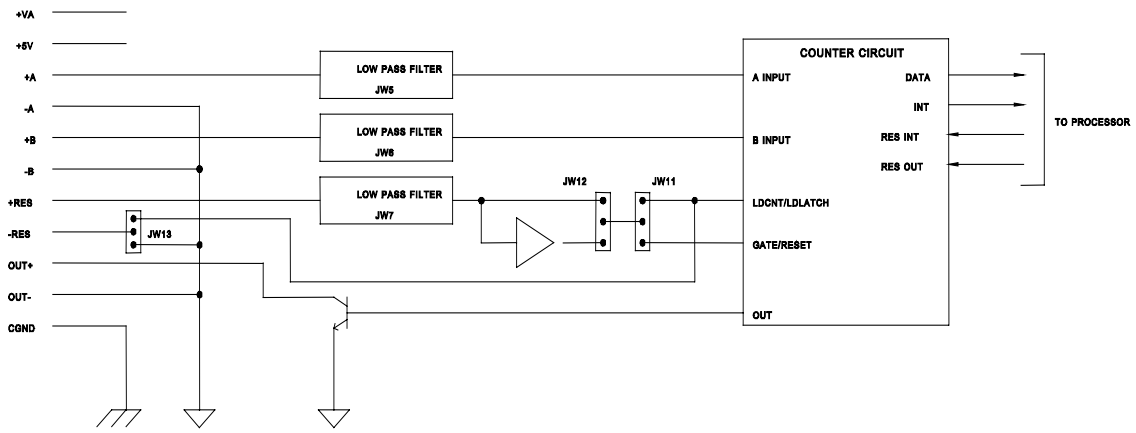


Figure 8 – High Speed Counter Logic

The **A**, **B**, and **RES** inputs are open-collector, with jumper selectable low pass filters (20Hz, 5kHz, and 100kHz). **JW5** sets the filter cutoff frequency for **A**, **JW6** for **B**, and **JW7** for **RES**. The **A** and **B** inputs are the signals to be counted; they are edge triggered. The counter can operate in four input modes:

1. The **A** and **B** inputs are used in quadrature X1 mode, for use with biphase encoders. The count value changes once for each biphase cycle.
2. The **A** and **B** inputs are used in quadrature X4 mode, for use with biphase encoders. The count value changes with each input transition; X4 mode counts four times faster than X1 mode, given the same input signal.
3. A falling edge on the **A** input (while the **B** input is low) causes the counter to increment, and a falling edge on the **B** input (while the **A** input is low) causes the counter to decrement. Inputs **A** and **B** should not be high at the same time.
4. The **B** input sets the count direction: high for increment, low for decrement. A falling edge on the **A** input causes the counter to count in the selected direction.

If the counter is to be used in unidirectional mode, it should be put into mode 4. The count signal would be connected to the **A** input, and the **B** input would control the direction.

The **+RES** input can be configured using **JW11** to reset the counter, to load the counter from the input latch, or to load the output latch from the counter. **+RES** can be either active high or active low, selectable using **JW12**. When **+RES** is routed to the LDCNT/LDLATCH control line, a pulse on **+RES** will cause the counter value to be preset from the input latch or written to the output latch, depending upon the software configuration of the circuit. When **+RES** is routed to the GATE/RESET control line, a pulse on **+RES** will cause the counter hold its current value (disregarding **A** and **B**) or reset to 0, depending upon the software configuration of the circuit.

The **-RES** input can be configured using **JW13** to connect to ground or to connect to the LDCNT/LDLATCH control line. It can be connected to ground for ease of wiring the reset line; a sensor can be attached across **+RES** and **-RES**. If it is connected to the LDCNT/LDLATCH control line, then **+RES** can be connected to GATE/RESET, allowing full access to the counter control signals. In this configuration, a single input signal can be wired to latch the current counter value into the output latch, and then reset the counter value to 0.

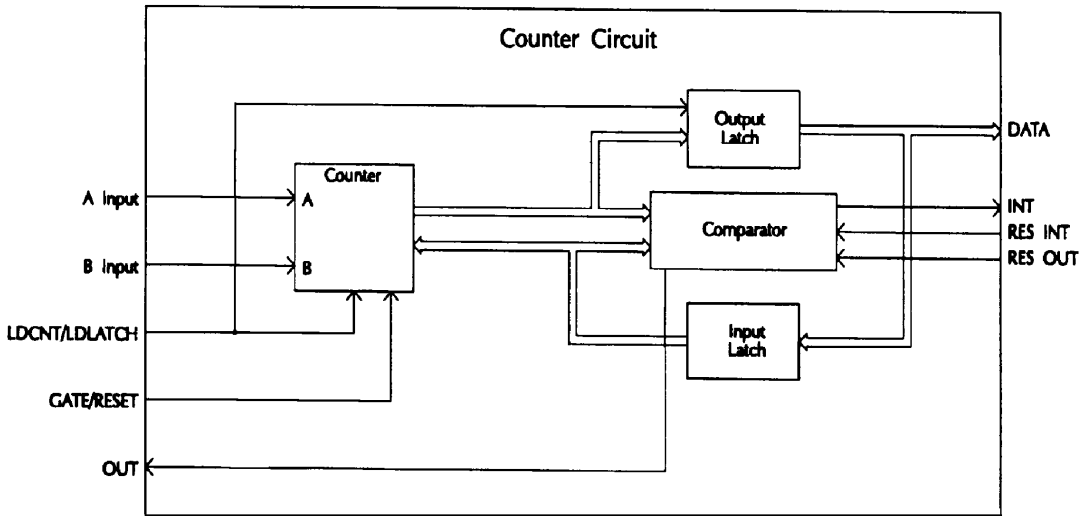


Figure 9 – Internal Counter Logic

When the counter value matches the value stored in the input latch, the comparitor will assert the high speed output and also send an interrupt signal to the processor. These signals stay active until the processor resets each of them with the appropriate control line (RES_OUT and RES_INT). RDCNTR can reset the high speed output. The interrupt signal can be reset with OUT $40,1, although the INTERRUPT statement resets it automatically. The output circuit is open-collector; **Figure 10** shows two ways to use the output.

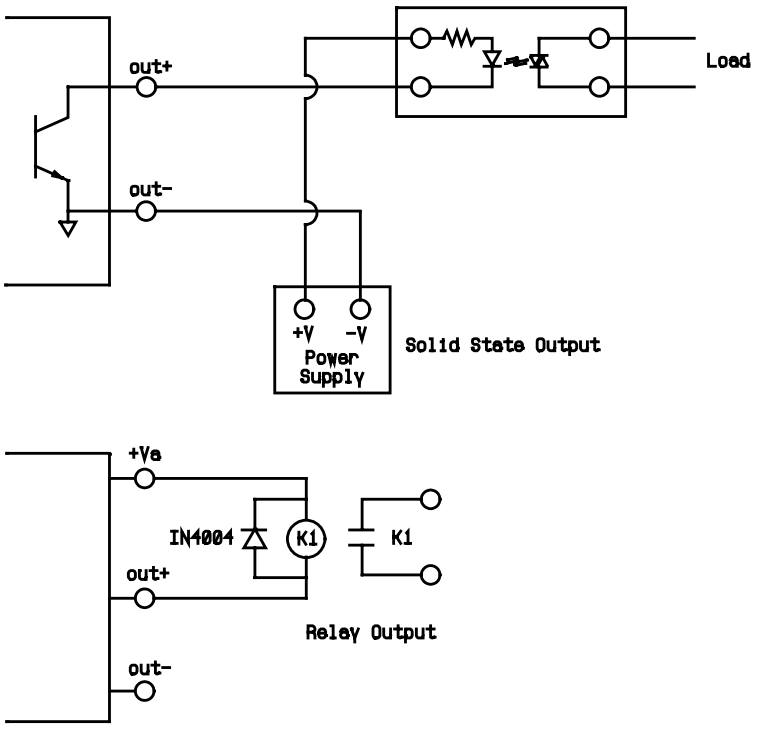


Figure 10 – Using the Counter Direct Output

The counter inputs **A**, **B**, and **RES** are designed to be used with open collector (ie. sinking) sensor outputs. These inputs present a 12 VDC signal which the sensor must pull to ground. The inputs must not be used with sourcing sensor outputs, as this will cause erratic operation of both the sensor and the Boss Bear. Contact Divelbiss for encoder recommendations. Figure 11 shows an example of wiring a biphase incremental encoder to the Boss Bear.

For best noise immunity, shielded cable should be used between the counter inputs and the device being monitored; this is especially important for long cable runs. To minimize any potential crosstalk problems, it is recommended that individually paired and shielded cables be used for each I/O device, especially at high counting speeds. Use the shield terminal provided or connect the shield to earth ground by other means. Do not connect the cable shield at both ends of the cable, as this can have an adverse effect. Always use separate returns (minus terminal) for each signal pair, as this lessens the chance of ground loops occurring by making all common terminations at the counter module.

When used correctly, the low pass filters on the **A**, **B**, and **RES** inputs can prevent potential noise pickup problems. Always use the lowest cutoff frequency that can be tolerated for your application, but remember that these are not high "Q" filters, and that a ±20% corner frequency tolerance is specified. The important point in determining the filter cutoff is not the pulse frequency being measured, but the pulse width. For example, if a 100□sec pulse arrives about once per second, the filter should be set to 100kHz, since a lower filter cutoff would damp the pulse out.

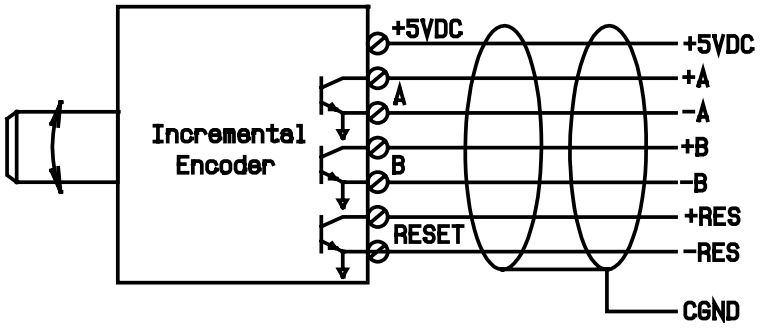


Figure 11 – Biphase Incremental Encoder Wiring Example

7.1.1 Counter Examples

The simplest example of using the counter just reads the current count value and displays it on the onboard display. To try this example, just wire a pushbutton between the **+A** and **-A** inputs to use as a pulse source. Each time that the button is pushed, the counter will increment one or more times; the button will probably bounce when pressed, causing up to 20 pulses.

```
100  INTEGER COUNT
110  CNTRMODE 1,3                  ' A counts up, B counts down
120  WRCNTR 1,0,10                 ' Set counter value to 10
130  FILE 6
140  RDCNTR 1,0,COUNT              ' Read the current value
```

```
150  FPRINT "U6Z",COUNT              ' Now display it
160  GOTO 140
```

The next example shows how to handle counter interrupts and use the high speed output. This example sets up task 1 as the interrupt handler for counter 1. In lines 120 and 130 it initializes counter 1, setting its mode to A-count, B-direction and writing a 0 to the counter. In lines 140 and 150 it sets the counter reload variable to 10 and writes this reload value into the counter's compare register. Line 160 uses INTERRUPT to set task 1 as the interrupt handler for the counter. Lines 210 to 240 form the program's main loop, which just displays the latest counter value (COUNT) from the last interrupt; it also increments and displays J, just to cause some action on the display. Lines 300 to 350 form task 1, the interrupt handler; it reads the current counter value and updates the reload value. Lines 400 to 440 form task 2, which turns off the high speed output about 1/2 second after it is turned on.

In task 1, the first thing that it does is read the current counter value. At low pulse rates, this will be the same as RELOAD, since it is reading the same value that caused the interrupt. As the pulse rate increases, however, the counter will increment before the task 1 gets to read the counter. At a very high pulse rate, a problem will occur when the counter has already gone beyond the new RELOAD value before RELOAD is written to the counter (ie. COUNT=783 and RELOAD=780); this effectively stops the interrupt, since the counter will need to wrap completely around before the interrupt will occur again.

```
100  ' Program to demonstrate the high speed counter interrupt
110  INTEGER J, RELOAD, COUNT, T2TEMP
120  CNTRMODE 1,4                    ' A count, B direction
130  WRCNTR 1,0,0                    ' Set count to 0
140  RELOAD=10: COUNT=0
150  WRCNTR 1,1,RELOAD               ' Set counter interrupt value
160  INTERRUPT 1,1,1                 ' Set counter interrupt to task 1
170  J=0
180  FILE 6                          ' Output to onboard display
200  ' Main program loop.
210  LOCATE 1,1
220  FPRINT "U5X5U5Z", J, COUNT
230  J=J+1                           ' Increment junk variable
240  GOTO 210
300  ' Counter interrupt handler task.
310  TASK 1
320  RDCNTR 1,0,COUNT                ' Get new count
330  RELOAD=RELOAD+10                ' Set up new reload
340  WRCNTR 1,1,RELOAD               ' Set counter interrupt value
350  RUN 2: EXIT                     ' Set up task 2 to turn output off.
400  ' Task to turn off high speed output
410  TASK 2
420  WAIT 50                         ' Wait 1/2 second, then turn
430  RDCNTR 1,3,T2TEMP               ' the output off
440  CANCEL 2: EXIT                  ' Don't reschedule this task.
```

7.2 Analog to Digital Converter

The optional A/D converter has 8 single ended, 10 bit, 0 to 5 VDC input channels. It is read using the ADC function, which scales the A/D output to return a value between 0 (at 0 VDC) and 32767 (at 5 VDC). Using the ADC function, the A/D conversion time is approximately 350 microseconds. The 10 bit converter provides about 0.1% accuracy. On newer

revisions of the Boss Bear (revision E and later), the onboard A/D provides 12 bit resolution, or about 0.025% accuracy.

The A/D input voltage is limited by zener diodes to protect the A/D converter. If an input goes above 5 VDC, that input will be short-circuited to ground. Therefore, the system should be designed so the input signal does not go above 5 VDC. All signal cables should be shielded running to the sensor; the shield should be attached to chassis ground (**CGND** on the A/D terminal strip) at the Boss Bear end only. See Figure 12.

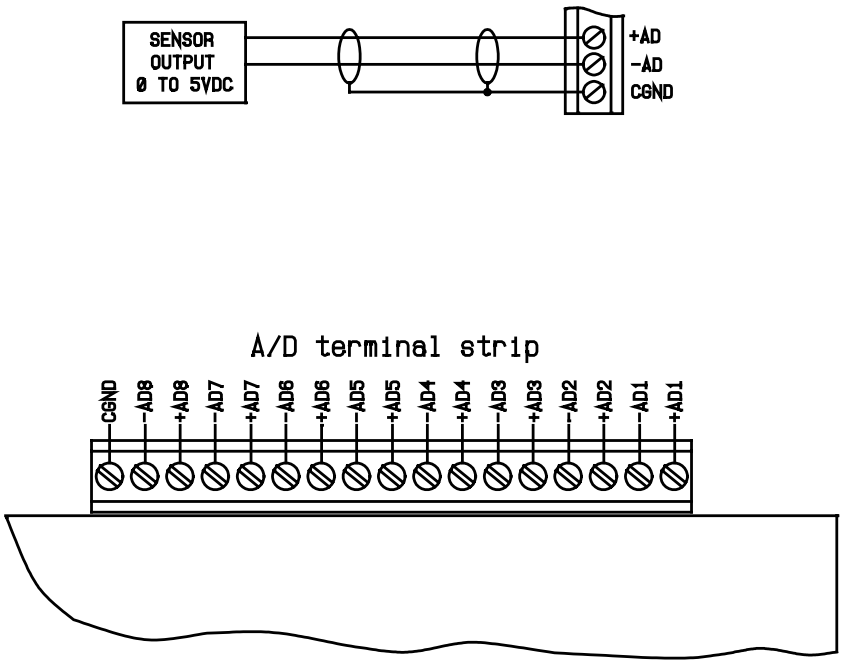


Figure 12 – A/D Wiring

When the 10 bit onboard A/D option is installed, it supplies the first 12 A/D channels (when read with the ADC() function), as follows:

Channel	Description
1	AD1
2	AD2
3	AD3
4	AD4
5	AD5
6	AD6
7	AD7
8	AD8
9	No connection
10	Internal +5 VDC supply divided by 2
11	+VA unregulated +12 VDC supply divided by 4

12	Internal self test voltage. A good test will return a value between 16000 and 16767. If the value is out of this range, then the A/D system is malfunctioning.

When the 12 bit onboard A/D option is installed, it supplies the first 12 A/D channels (when read with the ADC() function), as follows:

Channel	Description
1	AD1
2	AD2
3	AD3
4	AD4
5	AD5
6	AD6
7	AD7
8	AD8
9	No connection
10	No connection
11	No connection
12	No connection

The following example shows the use of the ADC function. It simply displays the voltage being read by the first 8 A/D channels. In line 140, it reads the A/D value and converts it from A/D units (0 to 32767) to voltage (0.0 to 5.0).

```
100  ' Display the first 8 A/D channels
110  INTEGER CHAN
120  REAL ADVAL
130  FOR NUM = 1 TO 8
140    ADVAL = ADC(CHAN)/32768.0*5.0
150    PRINT "Channel "; CHAN; " = "; ADVAL
160  NEXT CHAN
```

It is often necessary to convert an A/D reading into the appropriate engineering units, either for display purposes or to make the program easier to understand. In the previous example, the number was displayed as a voltage. In general the following formula performs the necessary scaling:

$$\frac{Reading}{32767} * (Maxval - Minval) + Minval$$

where Reading is the A/D reading, Maxval is the maximum value that the sensor can measure, and Minval is the minimum value that the sensor can measure. For example if a temperature sensor returns 0 VDC at -50 degrees C and 5 VDC at 200 degrees C, then this formula becomes:

$$\frac{Reading}{32767} * (200 - (-50)) + (-50) = Reading * \frac{250}{32767} - 50$$

or, reduced to the simplest form and written as BASIC code: CDEG=ADC(CH)*0.0076294-50.0.

The following points must be observed to get the greatest accuracy from the Boss Bear A/D converter:

- The Boss Bear chassis ground (ground lead on the power input connector) must be attached to earth ground.
- The unused inputs on the A/D connector should be shorted (ie. ADn+ tied to ADn-).
- Shielded cable should be used to attach to the sensor. The shield should be attached to CGND at the Boss Bear A/D connector. The other end of the shield should not be tied to ground, as this could cause a ground loop. Depending upon the construction and mounting of the sensor, the shield may or may not be attached to the sensor. If the sensor shield (which is probably it's housing) is isolated from ground, then the shield should be attached to the sensor. If the sensor is attached to ground, then do not attach the shield, as this could cause a ground loop.
- The cable should be kept short, although it should be routed away from noise-producing equipment and power lines, if possible.
- The sensor should be chosen so that its output in the normal operating range is at the upper end of the Boss Bear's A/D range. With the 12 bit, 0 to 5 VDC A/D, an input of 0.5 VDC results in 0.24% accuracy, while an input of 4.5 VDC results in 0.027% accuracy.
- For the highest accuracy and greatest noise rejection, an instrument amplifier should be installed at the Boss Bear. Since the Boss Bear's onboard A/D converter has single-ended inputs, it has no common mode rejection. To improve the noise rejection, especially on long cable runs, a differential instrument amplifier in a four wire sensor configuration should be used. This will provide high common mode rejection, will remove the losses caused by the long cable run and allows the sensor output range to be adjusted to match the Boss Bear A/D input range. This amplifier should be mounted in the enclosure with the Boss Bear.

7.3 Bear Bones Interface

The Bear Bones interface allows direct access to the Bear Bones Controller I/O Bus. This looks like an I/O panel to the Bear Bones, with 16 inputs and 16 outputs; it is factory assigned at I/O page 0, but can optionally be set in the field to any page. The Boss Bear accesses the interface page with the BBOUT statement and BBIN function. The Bear Bones interfaces using standard ladder logic to access page 0. The Boss Bear is connected to the Bear Bones by wiring into the Bear Bones I/O expansion bus, as shown in Figure 13.

This feature allows a powerful, dual processor system to be assembled at a very low cost. The Bear Bones handles the discrete logic control, and the Boss Bear handles the analog functions, high speed counters, user interface, and network communications. Each processor performs the tasks that it is best suited to, providing performance that is greater than the sum of their individual capabilities. It also allows the I/O count to be increased, since each unit supports a chain of I/O expanders.

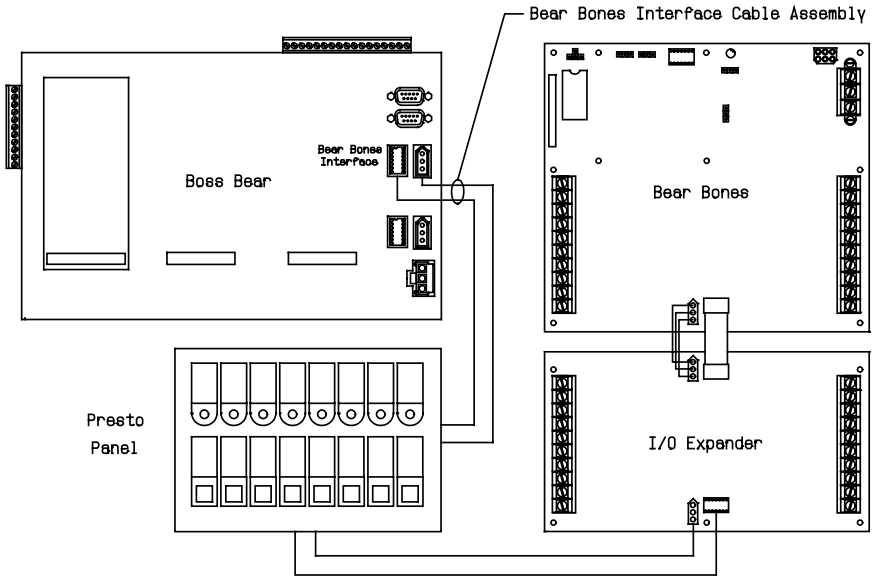


Figure 13 – Boss Bear to Bear Bones Connection Example

7.4 Boss Bear Input and Output

The Boss Bear I/O Bus allows up to 128 inputs and 128 outputs, using the standard Divelbiss Bear Bones Expanders and Presto Panel; I/O boards of different types can be intermixed in any combination. Figure 14 shows how the boards are connected to the Boss Bear. The DIN function is used to read the status of inputs, and the DOUT statement is used to control outputs. Figure 15 shows how the expander I/O address is related to the Boss Bear I/O number; note that the easiest way to specify an I/O address on the Boss Bear is in hexadecimal.

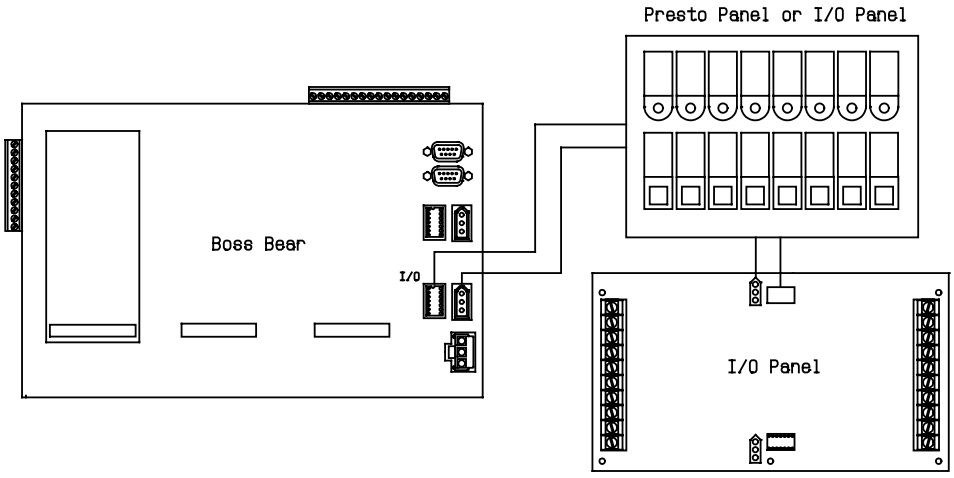


Figure 14 – I/O Expander Connection Example

When programming with I/O boards, remember to take the response time of the board into account. Inputs may have debounce circuitry that delays the response to a signal change by 10 to 20 msec. Outputs may take 20 msec to change state; this will limit the pulse rate that can be generated.

Addr	Hex	Dec.	Addr	Hex	Dec.	Addr	Hex	Dec.	Addr	Hex	Dec.
0/0	$00	0	2/0	$20	32	4/0	$40	64	6/0	$60	96
0/1	$01	1	2/1	$21	33	4/1	$41	65	6/1	$61	97
0/2	$02	2	2/2	$22	34	4/2	$42	66	6/2	$62	98
0/3	$03	3	2/3	$23	35	4/3	$43	67	6/3	$63	99
0/4	$04	4	2/4	$24	36	4/4	$44	68	6/4	$64	100
0/5	$05	5	2/5	$25	37	4/5	$45	69	6/5	$65	101
0/6	$06	6	2/6	$26	38	4/6	$46	70	6/6	$66	102
0/7	$07	7	2/7	$27	39	4/7	$47	71	6/7	$67	103
0/8	$08	8	2/8	$28	40	4/8	$48	72	6/8	$68	104
0/9	$09	9	2/9	$29	41	4/9	$49	73	6/9	$69	105
0/10	$0A	10	2/10	$2A	42	4/10	$4A	74	6/10	$6A	106
0/11	$0B	11	2/11	$2B	43	4/11	$4B	75	6/11	$6B	107
0/12	$0C	12	2/12	$2C	44	4/12	$4C	76	6/12	$6C	108
0/13	$0D	13	2/13	$2D	45	4/13	$4D	77	6/13	$6D	109
0/14	$0E	14	2/14	$2E	46	4/14	$4E	78	6/14	$6E	110
0/15	$0F	15	2/15	$2F	47	4/15	$4F	79	6/15	$6F	111
1/0	$10	16	3/0	$30	48	5/0	$50	80	7/0	$70	112
1/1	$11	17	3/1	$31	49	5/1	$51	81	7/1	$71	113
1/2	$12	18	3/2	$32	50	5/2	$52	82	7/2	$72	114
1/3	$13	19	3/3	$33	51	5/3	$53	83	7/3	$73	115
1/4	$14	20	3/4	$34	52	5/4	$54	84	7/4	$74	116
1/5	$15	21	3/5	$35	53	5/5	$55	85	7/5	$75	117
1/6	$16	22	3/6	$36	54	5/6	$56	86	7/6	$76	118
1/7	$17	23	3/7	$37	55	5/7	$57	87	7/7	$77	119
1/8	$18	24	3/8	$38	56	5/8	$58	88	7/8	$78	120
1/9	$19	25	3/9	$39	57	5/9	$59	89	7/9	$79	121
1/10	$1A	26	3/10	$3A	58	5/10	$5A	90	7/10	$7A	122
1/11	$1B	27	3/11	$3B	59	5/11	$5B	91	7/11	$7B	123
1/12	$1C	28	3/12	$3C	60	5/12	$5C	92	7/12	$7C	124
1/13	$1D	29	3/13	$3D	61	5/13	$5D	93	7/13	$7D	125
1/14	$1E	30	3/14	$3E	62	5/14	$5E	94	7/14	$7E	126
1/15	$1F	31	3/15	$3F	63	5/15	$5F	95	7/15	$7F	127

The Addr column shows the Expander I/O address; the Hex column shows the Boss Bear I/O number in hexadecimal form, while the Dec. column shows it in decimal form.

Figure 15 – Relation between I/O Board Address and Boss Bear I/O Number

7.5 Real Time Clock

The optional real time clock allows the Bear BASIC program to determine the time and date at any point. The clock is accessed using GETDATE, SETDATE, GETIME, and SETIME.

7.6 Serial Ports

Many devices interface with other equipment using serial data transfer. The Boss Bear provides one standard serial port (**COM1**) and one optional serial port (**COM2**). Both ports support asynchronous serial transfer at baud rates between 150 and 38400 baud.

Note: Using CTR-C or Chain Command resets com ports to default settings.

7.6.1 COM1

COM1 supports RS-232 levels. While at the command line prompt, it is used to attach the console terminal, which is the main programmer's interface to the Boss Bear. On power up, it is set to 9600 baud, no parity, 8 data bits, and 1 stop bit. At runtime, **COM1** is accessed as FILE 0; it may be used as a general purpose serial port. The **COM1** connector is a 9 pin male D connector; the pinout is given in **Figure 16**.

Pin	ID	Description
1	--	No connect
2	RX	Receive data
3	TX	Transmit data
4	DTR	Data Terminal Ready (+10 VDC)
5	GND	Signal ground
6	--	No connect
7	RTS	Request To Send (Output)
8	CTS	Clear To Send (Input)
9	--	No connect

Figure 16 – COM 1 Connector Pin Out

Divelbiss can supply the following cables to connect the Boss Bear COM1 port to a personal computer:

Part No.	Description
ICM-CA-28	9 pin female D to male 25 pin D, 6 ft long
ICM-CA-29	9 pin female D to female 25 pin D, 6 ft long

To set the operating mode for **COM1**, two I/O ports must be written to. Port 0 controls the number of data bits, stop bits, and whether parity is enabled; see Figure 17. I/O port 2 controls the baud rate and even/odd parity (if port 0 setup has enabled parity); see Figure

18. For example, the code OUT 0,97: OUT 2,13 sets **COM1** to operate at 300 baud, no parity, 7 data bits, and 1 stop bit; since parity is disabled, OUT 0,97: OUT 2,29 will set the same parameters. As another example, OUT 0,102: OUT 2,5 will set 1200 baud, 8 data bits, even parity, and 1 stop bit. Bit 4 of port 0 (the $10 bit) controls the state of the RTS line for **COM1**; clearing bit 4 asserts RTS. The CTS input is always enabled; if CTS goes low, COM 1 will stop transmitting.

Decimal	Hex	Binary	Description
96	$60	01100000	Start bit + 7 data bits + no parity + 1 stop bit
97	$61	01100001	Start bit + 7 data bits + no parity + 2 stop bits
98	$62	01100010	Start bit + 7 data bits + parity + 1 stop bit
99	$63	01100011	Start bit + 7 data bits + parity + 2 stop bits
100	$64	01100100	Start bit + 8 data bits + no parity + 1 stop bit
101	$65	01100101	Start bit + 8 data bits + no parity + 2 stop bits
102	$66	01100110	Start bit + 8 data bits + parity + 1 stop bit
103	$67	01100111	Start bit + 8 data bits + parity + 2 stop bits

Figure 17 – COM Port Setup Parameters

Decimal	Hex	Binary	Description
0	$00	00000000	38400 baud, even parity (if parity set)
1	$01	00000001	19200 baud, even parity (if parity set)
2	$02	00000010	9600 baud, even parity (if parity set)
3	$03	00000011	4800 baud, even parity (if parity set)
4	$04	00000100	2400 baud, even parity (if parity set)
5	$05	00000101	1200 baud, even parity (if parity set)
6	$06	00000110	600 baud, even parity (if parity set)
13	$0D	00001101	300 baud, even parity (if parity set)
14	$0E	00001110	150 baud, even parity (if parity set)
16	$00	00010000	38400 baud, odd parity (if parity set)
17	$11	00010001	19200 baud, odd parity (if parity set)
18	$12	00010010	9600 baud, odd parity (if parity set)
19	$13	00010011	4800 baud, odd parity (if parity set)
20	$14	00010100	2400 baud, odd parity (if parity set)
21	$15	00010101	1200 baud, odd parity (if parity set)
22	$16	00010110	600 baud, odd parity (if parity set)
29	$1D	00011101	300 baud, odd parity (if parity set)
30	$1E	00011110	150 baud, odd parity (if parity set)

Figure 18 – COM Port Baud Rate Parameters

7.6.2 COM2

COM2 supports RS-232, RS-422, and RS-485. It is unused while at the command line prompt. At runtime, it may be accessed as FILE 5 as a general purpose serial port, or it can be used to link the Boss Bear into the Bear Direct network. On power up, it is set to

9600 baud, no parity, 8 data bits, and 1 stop bit. The **COM2** connector is a 9 pin female D connector; the pinout is given in Figure 19.

RS-422

Pin	ID	Description
1	TX-	Transmit data (-)
2	--	No connect
3	--	No connect
4	RX-	Receive data (-)
5	GND	Signal ground
6	RX+	Receive data (+)
7	--	No connect
8	--	No connect
9	TX+	Transmit data (+)

RS-485

Pin	ID	Description
1	TX-	Data (-)
2	--	No connect
3	--	No connect
4	--	No connect
5	GND	Signal ground
6	--	No connect
7	--	No connect
8	--	No connect
9	TX+	Data (+)

RS-232

Pin	ID	Description
1	--	No connect
2	TX	Transmit data
3	RX	Receive data
4	--	No connect
5	GND	Signal ground
6	--	No connect
7	CTS	Clear To Send (Input)
8	RTS	Request To Send (Output)
9	--	No connect

Figure 19 – COM 2 Connector Pin Out

To set the operating mode for **COM2**, two I/O ports must be written to. Port 1 controls the number of data bits, stop bits, and whether parity is enabled; see **Figure 17**. I/O port 3 controls
the baud rate and even/odd parity (if port 1 setup has enabled parity); see **Figure 18**. For example, the code OUT 1,97: OUT 3,13 sets **COM2** to operate at 300 baud, no parity, 7 data bits, and 1 stop bit; since parity is disabled, OUT 1,97: OUT 3,29 will set the same parameters. As another example, OUT 1,99: OUT 3,20 will set 2400 baud, 7 data bits, odd parity, and 2 stop bits.

JW1 is used to select between RS-232 and RS-422/485 modes. RS-232 can connect two pieces of equipment using three conductor cable; it is generally used for short distances (up to 50 ft) in environments that don't have much electrical noise. RS-422 can connect two pieces of equipment using five conductor cable; it can drive much longer distances (up to 5000 ft) and is more immune to noise. RS-485 can connect up to 32 pieces of equipment in a multidrop network using three conductor cable; it can also drive long distances in noisy environments.

To operate **COM2** in RS-422 mode, the line driver must be put into transmit mode, using the code `OUT $B,0: OUT $A,$10`; this need only be done once, at the beginning of the program.

When operating in RS-485 mode, the line driver must be switched between transmit and receive mode; in an RS-485 multidrop network, only one unit can be in transmit mode at any given time. As before, the code `OUT $B,0: OUT $A,$10` sets it to transmit. After all characters have been sent, allow at least two extra character times (ie. 2 msec at 9600 baud), then set the driver to receive mode using `OUT $B,$FF: OUT $A,$10`.

7.7 Nonvolatile Memory

Nonvolatile memory retains its state with the system power turned off. The Boss Bear supports two types of nonvolatile memory as options: EEPROM and battery backed up RAM. Each of these has characteristics that make it more suitable for some applications.

7.7.1 EEPROM

An EEPROM (Electrically Erasable Programmable Read Only Memory) requires no power to retain its state; it can even be moved from one unit to another without affecting its contents. Current EEPROM technology provides at least ten years of data retention. Unfortunately, it takes approximately 10 milliseconds to write each byte into an EEPROM, and each byte can only be written into approximately 10,000 times. This makes the EEPROM most suitable for data that rarely changes, such as configuration information and calibration data. Bear BASIC supports either a 2KB or 8KB EEPROM, using the EEPOKE and EEPEEK statements to access the EEPROM.

7.7.2 Battery Backed Up RAM

The Boss Bear has a battery back up option for the system RAM. With this option installed, the Boss Bear memory will be retained for approximately 6 months without power; the battery is charging whenever the unit is powered up. The battery backed up RAM is most suitable for values that change often, such as production information. When a BASIC program is started, the RAM is not modified, except by the BASIC program itself. This means that the variables will all have the same values that they held when power was removed.

Note that every time the Boss Bear is turned on, the compiler is initialized, which deletes the BASIC source code. This does not affect the runtime memory area, so the variable values will be unchanged. This allows the programmer to leave information in BASIC variables; it will be retained while the Boss Bear is without power. With newer versions of the compiler (v2.02 and up), the BASIC source code is not deleted when power is applied.

Chapter 8
Bear BASIC Language Reference

= Statement

Summary:

The = statement assigns a value to a variable.

Syntax:

variable = *expr*

Arguments:

expr a numeric or string expression. The expression type must match the type of *variable*.

Description:

The = statement is used to store the result of an expression into a variable. If *variable* is an integer or real, then the result of the expression is converted to the proper type before being stored. Care should be taken when assigning the result of an expression containing real values to an integer variable. In this case, Bear BASIC may lose precision during the expression evaluation; see section 3.6 for a discussion of this problem.

Note that the character '=' is also used to represent the equality operator. This means that the statement `X=A=B` is legal; it sets X to a nonzero value if A is equal to B.

In multitasking programs, the context switcher will not switch tasks during the assignment operation. For example, if a program has a real variable X and a task executes the statement X=3.1416, the task will always update all 4 bytes of X as a group, without allowing another task to break in. This is also true of integers and strings. In an expression evaluation, however, the context switcher may allow another task to corrupt a variable. If one task is executing the statement X=X*1.5 and another task interrupts and executes X=4.3, then the value of X depends on the exact spot that the context switcher interrupted. The programmer should avoid this type of situation by using different variables or using the PRIORITY statement to control the operation of the context switcher.

Example:

```
100  INTEGER J
110  REAL X
120  X=2.7*4.0
130  J=(X*10000)-21234
140  PRINT J
```

Related topics:

Section 3.6

ACOS Function

Summary:

The ACOS function calculates the arccosine function.

Syntax:

x = ACOS (*expr*)

Arguments:

expr a numeric expression.

Description:

The ACOS function returns the arccosine of its argument, which must be a numeric expression. The result is returned as a REAL value, in degrees.

Example:

```
100  REAL X,Y
110  PRINT ACOS(1.23)
120  X=4.0
130  Y=ACOS(X)
140  PRINT "Arccosine value of ";X;" is ";Y
```

This produces the following output when run:

```
157.36422
Arccosine value of 4.00000 is 104.93141
```

ADC Function

Summary:

The ADC function is used to read an analog input value from one of the A/D channels.

Syntax:

advl = ADC(*chan*)

Arguments:

chan a numeric expression. The A/D channel number to read starting with 1.

Description:

The ADC function performs an analog conversion on the specified A/D channel, and returns the result as an INTEGER value between 0 and 32767. The value returned by the A/D hardware is scaled to cover the full range of 0 to 32767; this allows A/D converters of different resolutions (ie. 10 bit, 12 bit, etc.) to be substituted without altering the user's program. The ADC function takes approximately 350 microseconds to complete. The A/D channels are assigned based on the hardware available on the Boss Bear; channel 1 could be on the onboard A/D, or in any of the expansion ports (if there is no onboard A/D converter). The order of precedence for assigning A/D channels is: onboard A/D followed by J3 followed by J4 followed by J5.

Example:

```
100  ' Display the first 5 A/D channels
110  INTEGER NUM
120  FOR NUM = 1 TO 5
130    PRINT "Channel ";NUM;" = "; ADC(NUM)
140  NEXT NUM
```

This produces the following output when run:

```
Channel 1 = 0
Channel 2 = 0
Channel 3 = 13440
Channel 4 = 0
Channel 5 = 0
```

Channels 1, 2, 4, and 5 indicate that 0 volts are present. Channel 3 indicates that 2.05 volts is present (13440/32767*5.0=2.05).

Related topics:

DAC, Chapter 7

ADR Function

Summary:

The ADR function returns the address of a variable in the BASIC program.

Syntax:

addr = ADR(*name*)

Arguments:

name a character constant. The name of a variable declared in the BASIC program.

Description:

The ADR function returns the address of a variable; it is returned as an integer value. This can be used to find the address of a string or array in which an assembly language program will be POKEd. It can also be used to access a variable without using the normal BASIC operations.

Example:

```
100  ' Swap the bytes in a variable
110  INTEGER J,K
120  K = $1234
130  POKE ADR(J), PEEK(ADR(K)+1)
140  POKE ADR(J)+1, PEEK(ADR(K))
150  FPRINT "S2H4S4H4", "J=", J, "  K=", K
```

This produces the following output when run:

```
J=3412  K=1234
```

The key to understanding this example lies in remembering that an INTEGER occupies 2 bytes in memory. In line 130, we put the second byte of K into the first byte of J, and in line 140 we put the first byte of K into the second byte of J. The numbers are represented in hexadecimal to make the swap operation a little more obvious.

Related topics:

CALL, PEEK, POKE

ASC Function

Summary:

The ASC function calculates the ASCII numeric equivalent of the first character of a string.

Syntax:

x = ASC (*st$*)

Arguments:

st$ a string expression.

Description:

The ASC function returns the ASCII equivalent of the first character in the specified string. The result is returned as an INTEGER value. ASC is the converse of the CHR$ function.

Example:

```
100  STRING A$
110  INTEGER N
120  PRINT "ASCII value of X: ";ASC("X")
130  A$="012ABCabc ."
140  FOR N = 1 TO LEN(A$)
150    PRINT N; "  "; ASC(MID$(A$,N,1))
160  NEXT N
```

This produces the following output when run:

```
ASCII value of X: 88
1  48
2  49
3  50
4  65
5  66
6  67
7  97
8  98
9  99
10  32
11  46
```

Related topics:

CHR$, Appendix F

ASIN Function

Summary:

The ASIN function calculates the arcsine function.

Syntax:

x = ASIN (*expr*)

Arguments:

expr a numeric expression.

Description:

The ASIN function returns the arcsine of its argument, which must be a numeric expression. The result is returned as a REAL value, in degrees.

Example:

```
100  REAL X,Y
110  PRINT ASIN(1.23)
120  X=4.0
130  Y=ASIN(X)
140  PRINT "Arcsine value of ";X;" is ";Y
```

This produces the following output when run:

```
-67.36422
Arcsine value of 4.00000 is -14.93141
```

ATAN Function

Summary:

The ATAN function calculates the arctangent function.

Syntax:

x = ATAN (*expr*)

Arguments:

expr a numeric expression.

Description:

The ATAN function returns the arctangent of its argument, which must be a numeric expression. The result is returned as a REAL value, in degrees.

Example:

```
100  REAL X,Y
110  PRINT ATAN(1.23)
120  X=4.0
130  Y=ATAN(X)
140  PRINT "Arctangent value of ";X;" is ";Y
```

This produces the following output when run:

```
50.88856
Arctangent value of 4.00000 is 75.96370
```

BAND Function

Summary:

The BAND function performs a bitwise logical AND function.

Syntax:

x = BAND (*expr1,expr2*)

Arguments:

expr1	a numeric expression.
expr2	a numeric expression.

Description:

The BAND function logically ANDs *expr1* and *expr2* as 16 bit integers; each of the bits is individually ANDed together. This is useful for clearing bits in an integer variable, such as when accessing hardware registers. This differs from the AND operator, which compares two numbers as boolean values (ie. true or false). For example, BAND(2,6) returns 2, while 2 AND 6 evaluates to an undefined non-zero value.

Example:

```
100  INTEGER J,K
110  PRINT "   ";
120  FOR K = 0 TO 7
130    FPRINT "I3Z",K
140  NEXT K
150  PRINT
160  FOR J = 0 TO 7
170    FPRINT "I3Z",J
180    FOR K = 0 TO 7
190      FPRINT "I3Z", BAND(J,K)
200    NEXT K
210    PRINT
220  NEXT J
```

This produces the following output when run:

```
     0  1  2  3  4  5  6  7
  0  0  0  0  0  0  0  0  0
  1  0  1  0  1  0  1  0  1
  2  0  0  2  2  0  0  2  2
  3  0  1  2  3  0  1  2  3
  4  0  0  0  0  4  4  4  4
  5  0  1  0  1  4  5  4  5
  6  0  0  2  2  4  4  6  6
  7  0  1  2  3  4  5  6  7
>
```

Related topics:

BOR, BXOR

BBIN Function

Summary:

The BBIN statement is used to interface with the Bear Bones Programmable Controller in a dual processor system.

Syntax:

x = BBIN (*bbaddr*)

Arguments:

bbaddr an integer value. An address in the range 0 to 15 (inclusive).

Description:

The BBIN function reads a single bit of information from an attached Bear Bones. The Boss Bear and Bear Bones communicate using a single Bear Bones I/O page (normally page 0), which contains 32 single bit values: 16 from Boss Bear to Bear Bones, and 16 from Bear Bones to Boss Bear. This function is only useful if a member of the Bear Bones family is attached to the **Bear Bones Interface** connector on the back of the Boss Bear. It is important to remember that the Boss Bear and Bear Bones are running asynchronously to each other; the Bear Bones could be at any point in its program when the Boss Bear executes the BBIN function.

Example:

```
100  ' Read all 16 bits from
105  ' the Bear Bones
110  INTEGER NUM
120  FOR NUM = 0 TO 15
130    PRINT NUM; ","; BBIN(NUM); "  ";
140  NEXT NUM
```

This produces the following output when run. Note that the actual values displayed would depend on the program that was executing in the Bear Bones.

```
0,1  1,1  2,0  3,0  4,0  5,0  6,1  7,0  8,0  9,1  10,1  11,0  12,0  13,1  14,1
15,1
```

Related topics:

BBOUT, DOUT, DIN, Chapter 7

BBOUT Statement

Summary:

The BBOUT statement is used to interface with the Bear Bones Programmable Controller in a dual processor system.

Syntax:

BBOUT *bbaddr,b*

Arguments:

bbaddr	an integer value. An address in the range 0 to 15 (inclusive).
b	an integer value. A value of 0 clears the output bit to the Bear Bones, while a nonzero value sets the output bit.

Description:

The BBOUT statement sends a single bit of information to an attached Bear Bones. The Boss Bear and Bear Bones communicate using a single Bear Bones I/O page (normally page 0), which contains 32 single bit values: 16 from Boss Bear to Bear Bones, and 16 from Bear Bones to Boss Bear. This statement is only useful if a member of the Bear Bones family is attached to the **Bear Bones Interface** connector on the back of the Boss Bear. It is important to remember that the Boss Bear and Bear Bones are running asynchronously to each other; the Bear Bones could be at any point in its program when the Boss Bear executes the BBOUT statement.

Example:

```
100  ' Clear all 16 bits going to the Bear Bones
110  INTEGER NUM
120  FOR NUM = 0 TO 15
130    BBOUT NUM,0
140  NEXT NUM
```

Related topics:

BBIN, DOUT, DIN, Chapter 7

BOR Function

Summary:

The BOR function performs a bitwise logical OR function.

Syntax:

x = BOR (*expr1,expr2*)

Arguments:

expr1	a numeric expression.
expr2	a numeric expression.

Description:

The BOR function logically ORs *expr1* and *expr2* as 16 bit integers; each of the bits is individually ORed together. This is useful for setting bits in an integer variable, such as when accessing hardware registers. This differs from the OR operator, which compares two numbers as boolean values (ie. true or false). For example, BOR(2,5) returns 7, while 2 OR 5 evaluates to an undefined non-zero value.

Example:

```
100  INTEGER J,K
110  PRINT "   ";
120  FOR K = 0 TO 7
130    FPRINT "I3Z",K
140  NEXT K
150  PRINT
160  FOR J = 0 TO 7
170    FPRINT "I3Z",J
180    FOR K = 0 TO 7
190      FPRINT "I3Z", BOR(J,K)
200    NEXT K
210    PRINT
220  NEXT J
```

This produces the following output when run:

```
     0  1  2  3  4  5  6  7
  0  0  1  2  3  4  5  6  7
  1  1  1  3  3  5  5  7  7
  2  2  3  2  3  6  7  6  7
  3  3  3  3  3  7  7  7  7
  4  4  5  6  7  4  5  6  7
  5  5  5  7  7  5  5  7  7
  6  6  7  6  7  6  7  6  7
  7  7  7  7  7  7  7  7  7
>
```

Related topics:

BAND, BXOR

BXOR Function

Summary:

The BXOR function performs a bitwise logical exclusive OR function.

Syntax:

x = BXOR (*expr1,expr2*)

Arguments:

expr1	a numeric expression.
expr2	a numeric expression.

Description:

The BXOR function logically XORs *expr1* and *expr2* as 16 bit integers; each of the bits is individually XORed together. This is useful for inverting bits in an integer variable, such as when accessing hardware registers.

Example:

```
100  INTEGER J,K
110  PRINT "   ";
120  FOR K = 0 TO 7
130    FPRINT "I3Z",K
140  NEXT K
150  PRINT
160  FOR J = 0 TO 7
170    FPRINT "I3Z",J
180    FOR K = 0 TO 7
190      FPRINT "I3Z", BXOR(J,K)
200    NEXT K
210    PRINT
220  NEXT J
```

This produces the following output when run:

```
     0  1  2  3  4  5  6  7
  0  0  1  2  3  4  5  6  7
  1  1  0  3  2  5  4  7  6
  2  2  3  0  1  6  7  4  5
  3  3  2  1  0  7  6  5  4
  4  4  5  6  7  0  1  2  3
  5  5  4  7  6  1  0  3  2
  6  6  7  4  5  2  3  0  1
  7  7  6  5  4  3  2  1  0
>
```

Related topics:

BAND, BOR

BYE Direct Command

Summary:
The BYE direct command resets the Boss Bear.

Syntax:
BYE

Arguments:
BYE needs no arguments.

Description:
BYE performs a software reset of the Boss Bear. If **SW1** (the RUN/PROGRAM switch) is set to the **RUN** position, then the last program on the EPROM will be loaded and run.

Related topics:
Clear Memory

CALL Statement

Summary:

The CALL statement is used to link Bear BASIC to an assembly language subroutine.

Syntax:

CALL *addr*, [*arg1*], [*arg2*]...

Arguments:

addr a numeric expression. The address of the subroutine to call.

argx a numeric or string expression. An argument to be passed to the assembly language routine.

Description:

The CALL statement begins execution of an assembly language subroutine starting at *addr*. Execution of the assembly language subroutine continues until a RET instruction is encountered, at which point execution will continue at the point following the CALL statement in the Bear BASIC program. No registers need be preserved while in the assembly language subroutine.

If optional arguments are given after the address of the routine being called, then the address of these arguments are passed to the routine, allowing any BASIC variable or value to be passed to the assembly routine. Since the addresses of the values are passed, the assembly routine can alter the values before returning to the calling program.

If optional arguments are supplied, then these arguments will be stored in a table following the assembly language CALL instruction, so the return address on the stack will point at the table. The table will consist of zero or more entries, with each entry consisting of a mode byte followed by the argument address. The table will end with a 0 byte in place of a mode byte. The mode byte is assigned as follows: 1 for integer, 2 for real, and 3 for string. The arguments can be arrays, constants, or variables; array elements and constants are passed using temporary variables, and so should not be modified. Variables can be modified. For example, the code

```
100  INTEGER J
110  REAL X(10)
120  STRING A$(40)
     ' Other code goes here
500  CALL $C000, X(3), J, A$
```

would generate assembly language that looks like this:

```
CALL  $C000
.BYTE 2                        ; X(3) mode is real
.WORD address of temp holding value of X(3)
.BYTE 1                        ; J mode is integer
.WORD address of J
.BYTE 3                        ; A$ mode is string
.WORD address of A$
.BYTE 0                        ; End of table flag
; Next line of BASIC code.
```

If it is necessary to update an array element from a subroutine, then it must be done using an intermediate variable. For example:

```
600  K=KARRAY(4)
610  CALL $B800,K
620  KARRAY(4)=K
```

In order to write robust code, the assembly language programmer must not assume that the BASIC programmer used the correct number or type of arguments. The assembly code should always look through the table for the 0 (end of table flag), and return to the next address past it.

Even if the assembly routine requires no arguments (ie. 800 CALL $C000), the "end of table flag" is still stored after the CALL instruction, so the assembly routine must look at the table to determine the correct return address.

A CALL to address $100 will restart the Bear BASIC program that is currently running. It will cause the hardware to be re-initialized.

Example:

```
100  INTEGER NUM,BYTE
110  DATA $E1           ' pop   hl        Get table address
111  DATA $23           ' inc   hl        Skip mode byte
112  DATA $5E           ' ld    e,(hl)    Get low byte of arg address
113  DATA $23           ' inc   hl
114  DATA $56           ' ld    d,(hl)    Get high byte of arg address
115  DATA $23           ' inc   hl        Point to 0 byte
116  DATA $23           ' inc   hl        Point to next code byte
117  DATA $E5           ' push  hl        Store new return address
118  DATA $1A           ' ld    a,(de)    Get low byte of argument
119  DATA $C6,$05       ' add   a,5       Add 5
120  DATA $12           ' ld    (de),a    Store low byte back
121  DATA $13           ' inc   de
122  DATA $1a           ' ld    a,(de)    Get high byte of argument
123  DATA $CE,$00       ' adc   a,0       Propagate carry into high byte
124  DATA $12           ' ld    (de),a    Store high byte back
125  DATA $C9           ' ret             Return to BASIC
130  FOR NUM = 0 TO 17
140    READ BYTE
150    POKE $B000+NUM,BYTE          ' Store assembly program at $B000
160  NEXT NUM
160  NUM=90
170  CALL $B000,NUM               ' Call assembly program
180  PRINT NUM
```

This example calls a simple subroutine that gets the address of the argument, adds 5 to the argument, and returns. In the interest of space and clarity, this was programmed very badly; no argument checking is done in the assembly language. If $B000 is called with the wrong number of arguments, the system will almost certainly crash.

Related topics:

SYSTEM, CODE, Appendix D

CANCEL Statement

Summary:

The CANCEL statement stops a task from being restarted when the schedule interval given in the RUN statement elapses.

Syntax:

CANCEL *task*

Arguments:

task an integer expression. The number of the task to cancel.

Description:

CANCEL stops the specified *task* from being started again when the schedule interval given in the RUN statement elapses. CANCEL does not abort the task - only EXIT or STOP can stop the execution of a task. When a RUN statement is entered, a schedule interval is specified; each time the task EXITs, it is scheduled to restart after that many ticks have elapsed. CANCEL causes the scheduling of the task to cease. When CANCEL is executed, the task continues executing normally until it EXITs. The task will not run again until it is specifically commanded to via another RUN statement. CANCEL is useful when a task need only be run a fixed number of times; the task can CANCEL itself, as in the example below.

Example:

```
100  INTEGER J, K
105  K = 0                          ' Initialize counter for task 1.
110  RUN 1,10                       ' Set reschedule interval to 10 ticks.
120  FOR J = 1 TO 1000
130    PRINT "*";
140    WAIT 1
150  NEXT J
160  STOP
200  ' Task 1 prints 5 '.' characters.
210  TASK 1
220  PRINT ".";
230  K = K + 1                      ' Increment number of times we've run.
240  IF K >= 5 THEN CANCEL 1  ' If 5 times then done, don't reschedule.
250  EXIT
```

Related topics:

RUN, EXIT, STOP, Chapter 5

CHAIN Statement

Summary:

The CHAIN statement loads and runs another program from the user's EPROM.

Syntax:

CHAIN *filenum*
or
CHAIN "*filename*"

Arguments:

filenum an integer expression. The number of the compiled code file to load and execute.

filename a text string up to 10 characters long. The file name of the compiled code file to load and execute.

Description:

CHAIN causes another program to start executing. This allows a program that is too large to fit into memory to be broken into multiple smaller programs. Because Bear BASIC doesn't overwrite variables when it loads the new program, values can be passed between programs. The variables to be passed between programs must be the first variables declared, and they must be declared in the same order.

When CHAIN is used with a file name, the last file on the EPROM with the specified name is executed; this allows a file to be modified and stored on the same EPROM, since the newest file is always executed. When CHAIN is used with a file number, then that specific file is executed, even if there is a newer one with the same name.

The CHAIN statement disables interrupt processing. When the new program starts executing, it will reset some of the onboard hardware. The serial ports get reset, timer 1 is turned off, and the onboard display (LCD/VFD) is cleared. The high speed counter's value and mode is left unchanged.

In order for the new program to start executing, the run/program switch (**SW1**) must be in the **RUN** position. If it is in the **PROG** position, then CHAIN will cause the Boss Bear to return to the command line prompt.

Examples:

```
100  PRINT "Hi there"
110  CHAIN 4                        ' Jump to program 4 on EPROM
```

This example shows how to use CHAIN to run a specific program number.

```
100  ' First program. Save on EPROM as "FIRST"
110  PRINT "This is the first program"
120  WAIT 100
130  CHAIN "SECOND"
```

```
100  ' Second program. Save on EPROM as "SECOND"
110  PRINT "This is the second program"
120  PRINT "*************************"
130  WAIT 100
140  CHAIN "FIRST"
```

Type in the first program, compile it, and type SAVE CODE FIRST to save it on the EPROM. Then type in the second program, compile it, type SAVE CODE SECOND, and run the program. It will execute, then CHAIN to the first program, which will execute and CHAIN back to the second program.

CHR$ Function

Summary:

The CHR$ function returns a string that corresponds to an integer value.

Syntax:

*st$* = CHR$ (*expr*)

Arguments:

expr an integer expression between 0 and 255.

Description:

CHR$ returns a 1 character long string that corresponds to the ASCII value of the specified expression. CHR$ is the converse of ASC.

Example:

```
100  ' Print the character equivalents of the values 32 to 126.
110  INTEGER J
120  FOR J=32 TO 126
130    FPRINT "i3x1s1x3z",J,CHR$(J)
140  NEXT J
```

This produces the following output when run:

```
 32      33 !    34 "    35 #    36 $    37 %    38 &    39 '    40 (    41 )
 42 *    43 +    44 ,    45 -    46 .    47 /    48 0    49 1    50 2    51 3
 52 4    53 5    54 6    55 7    56 8    57 9    58 :    59 ;    60 <    61 =
 62 >    63 ?    64 @    65 A    66 B    67 C    68 D    69 E    70 F    71 G
 72 H    73 I    74 J    75 K    76 L    77 M    78 N    79 O    80 P    81 Q
 82 R    83 S    84 T    85 U    86 V    87 W    88 X    89 Y    90 Z    91 [
 92 \    93 ]    94 ^    95 _    96 `    97 a    98 b    99 c   100 d   101 e
102 f   103 g   104 h   105 i   106 j   107 k   108 l   109 m   110 n   111 o
112 p   113 q   114 r   115 s   116 t   117 u   118 v   119 w   120 x   121 y
122 z   123 {   124 |   125 }   126 ~   >
```

Related topics:

ASC

CLEARFLASH Direct Command

Summary:

The CLEARFLASH direct command erases the flash EPROM that the user's code is stored on.

Syntax:

CLEARFLASH

Arguments:

CLEARFLASH needs no arguments.

Description:

The UCP stores the user's programs on a flash EPROM which can be erased electrically, without being removed from the UCP. The CLEARFLASH command performs this erase operation, removing all data from the EPROM. This command takes about 10 seconds to complete. The flash EPROM can be erased at least 1000 times.

Example:

CLEARFLASH

Related topics:

SAVE, SAVE CODE

CLEARMEMORY Direct Command

Summary:
The CLEARMEMORY direct command fills the entire RAM memory area with zeroes.

Syntax:
CLEARMEMORY

Arguments:
CLEARMEMORY needs no arguments.

Description:
The CLEARMEMORY command allows the programmer to start the Boss Bear from a "clean" state. It writes 0 to all RAM locations, and then restarts the Boss Bear from the power-up state. Some BASIC program errors can change memory values in important locations, causing strange behavior. Normally, resetting the Boss Bear (by turning the power off and back on) will correct any problems of this nature, but using CLEARMEMORY guarantees that all values will be correctly initialized.

This command is also helpful when debugging a program which stores values in the battery backed up RAM. Such a program must handle the situation where the RAM hasn't been initialized yet (for example, when the program is loaded into a new Boss Bear). Using CLEARMEMORY allows the programmer to test the program's operation in this situation. If SW1 is in the run mode the Boss Bear will run the last program code saved to the eprom.

Related Topics:
BYE

CLS Direct Command

Summary:

The CLS direct command erases the console terminal display.

Syntax:

CLS

Arguments:

CLS needs no arguments.

Description:

CLS sends the control sequence to erase the display on an ADM-3A terminal. If an incompatible terminal is attached, then this won't erase the display.

CLS Statement

Summary:

The CLS statement erases the current display device.

Syntax:

CLS

Arguments:

CLS needs no arguments

Description:

CLS sends the clear-screen command to the currently active FILE. It works for the console terminal (FILE 0) and the front panel display (FILE 6, which can be either LCD or VFD). Note that in order for this to work correctly with FILE 0, the terminal must be set to emulate an ADM3 or ADM5 terminal.

NOTE: when entering BASIC programs that don't have line numbers, any line that begins with the CLS statement must have a line number. This is because CLS is also a direct command, so the line will be seen by the compiler as a direct command, not as part of the program. This only occurs on lines that begin with CLS, not on lines that just have CLS somewhere in the line. This problem doesn't occur with the ERASE statement, which performs the same operation, so it is recommended that ERASE be used in programs instead of CLS.

Example:

```
100  INTEGER J
110  FOR J = 1 TO 1000
120    FILE 0: PRINT "*";
130    FILE 6: PRINT "*";
140  NEXT J
150  WAIT 100
160  CLS
170  FILE 0: CLS
```

Related topics:

ERASE

CNTRMODE Statement

Summary:

The CNTRMODE statement sets the operating mode of the high speed counter.

Syntax:

CNTRMODE *num*, *mode*

Arguments:

num an integer expression. The counter number to set up: 1 through 13. If there is an onboard counter then it is 1, and the counter expansion modules would be 2 through 13 (or 5 or 9, depending upon how many modules are installed). If there is no onboard counter, then the counter expansion modules would be 1 through 12 (or 4 or 8, depending upon how many modules are installed).

mode an integer expression. The mode to set the counter to; one of the following:

0 - disable the counter
1 - X1 quadrature mode
2 - X4 quadrature mode
3 - a pulse on counter input A causes the count to increase, and a pulse on input B causes the count to decrease.
4 - counter input B sets the direction of counting (increase or decrease), and a pulse on input A causes the counter to count by 1.
5 - X1 quadrature mode. **RES** input will enable/disable counter.
6 - X4 quadrature mode. **RES** input will enable/disable counter.
7 - a pulse on counter input A causes the count to increase, and a pulse on input B causes the count to decrease. **RES** input will enable/disable counter.
8 - counter input B sets the direction of counting (increase or decrease), and a pulse on input A causes the counter to count by 1. **RES** input will enable/disable counter.

Description:

The Boss Bear's high speed counter circuit is extremely flexible; it is capable of operating in several modes, depending upon how the software and hardware is configured. The hardware is configured using various jumpers. The software is configured with the CNTRMODE statement. See chapter 7 for a description of the counter hardware.

Example:

```
100  CNTRMODE 1,2                    ' Set counter 1 to X4 quadrature mode
```

Related topics:

WRCNTR, RDCNTR, Chapter 7

CODE Statement

Summary:

The CODE statement stores assembly language code in the Bear BASIC program.

Syntax:

CODE *instr* [,*instr*]

Arguments:

instr an integer number. The instruction to store.

Description:

Bear BASIC provides the SYSTEM and CALL statements to allow assembly language subroutines to be called from the BASIC program. In addition to these, CODE stores assembly language instructions inline with the BASIC program. These instructions will be executed as they are encountered. Registers need not be preserved in the assembly language code. Appendix D discusses using assembly language in conjunction with Bear BASIC.

Note that Bear BASIC normally generates code for each line that stores the current line number in case an error occurs. This is inhibited between CODE statements, since it would corrupt the user's assembly routine.

Example:

```
100  INTEGER J
110  FOR J=0 TO 255
120    POKE $FB00, J                ' Store for assembly routine to access
130    CODE $3A,$00,$FB             ' LD A,(0FB00H);
140    CODE $4F,$06,$08             ' LD C,A;  LD B,8
150    CODE $AF,$ED,$39,$80         ' XOR A;  OUT0 (80H),A
160    CODE $CB,$17                 ' LOOP:  RRC C;  RL  A
170    CODE $F6,$02,$ED,$39,$80     ' OR 2;  OUT0 (80H),A
180    CODE $E6,$01,$ED,$39,$80     ' AND 1;  OUT0 (80H),A
190    CODE $10,$F0                 ' DJNZ LOOP
200  NEXT J
```

This example assumes that there is an output port attached to the first expansion port (I/O address $80). The assembly code shifts a byte out serially over this port, with bit 0 being the data and bit 1 being the clock signal. The outer loop (line 110) causes all 256 byte values to be sent.

Related topics:

SYSTEM, CALL, POKE, PEEK, Appendix D

COMPILE Direct Command

Summary:

The COMPILE direct command compiles the BASIC program currently in memory.

Syntax:

COMPILE (may be abbreviated to C)

Arguments:

COMPILE needs no arguments.

Description:

COMPILE causes the Bear BASIC compiler to convert the BASIC source code entered by the programmer into the native machine code used by the Boss Bear's 64180 processor. This is necessary before the program can be executed. For a large program, it may take as much as 20 seconds to compile. If the program is successfully compiled, then the message COMPILED will be displayed, otherwise an error message will be displayed. After the program has compiled successfully, the command STAT can be used to show some compilation statistics.

Related topics:

RUN command, GO

CONCAT$ Function

Summary:

The CONCAT$ function returns a string that is the concatenation of two strings.

Syntax:

*st$* = CONCAT$ (*st1$*, *st2$*)

Arguments:

st1$	a string expression.
st2$	a string expression.

Description:

CONCAT$ combines two strings into one, appending *st2$* immediately after *st1$*. In some other implementations of the BASIC language, strings are concatenated using the '+' operator.

Example:

```
100  STRING A$(40), B$              ' A$ must be large enough to hold both.
110  A$="This is one string, "
120  B$="and this is another."
130  A$=CONCAT$(A$, B$)
140  PRINT "<";A$;">"
```

Related topics:

Chapter 3

COS Function

Summary:
The COS function calculates the cosine function.

Syntax:
x = COS (*expr*)

Arguments:
expr a numeric expression.

Description:
The COS function returns the cosine of its argument, which must be a numeric expression, in degrees. The result is returned as a REAL value.

Example:
```
100  REAL X,Y
110  PRINT COS(45.0)
120  X=68.3
130  Y=COS(X)
140  PRINT "Cosine value of ";X;" is ";Y
```

This produces the following output when run:

```
.70711
Cosine value of 68.29999 is .36975
```

Related topics:
ACOS, SIN, ASIN, TAN, ATAN

CVI Function

Summary:

The CVI function converts a binary string to an integer.

Syntax:

x = CVI (*st$*)

Arguments:

st$ a string expression.

Description:

CVI performs the opposite function of MKI$; it takes the first two bytes of a string and returns them as an integer value. See MKI$ for a full explanation of binary strings.

Example:

```
100  STRING A$
110  A$=MKI$(1234)
120  PRINT CVI(A$)
```

This produces the following output when run:

```
1234
```

Related topics:

MKI$, CVS, MKS$

CVS Function

Summary:

The CVS function converts a binary string to a real.

Syntax:

x = CVS (*st$*)

Arguments:

st$ a string expression.

Description:

CVS performs the opposite function of MKS$; it takes the first four bytes of a string and returns them as a real value. See MKI$ for a full explanation of binary strings.

Example:

```
100  STRING A$
110  A$=MKS$(123.456)
120  PRINT CVS(A$)
```

This produces the following output when run:

```
123.45599
```

Related topics:

MKS$, CVI, MKI$

DAC Statement

Summary:

The DAC statement is used to control analog output channels.

Syntax:

DAC *chan*, *value*

Arguments:

chan	an integer expression. The number of the channel to access, starting at 1.
value	an integer expression. The level to set on the analog output, ranging between 0 and 1023 for the Boss Bear, or 0 and 32767 for the UCP.

Description:

Up to three analog output modules can be attached to the Boss Bear expansion ports; each module can have between one and four analog outputs. Each output is provided by a DAC (Digital to Analog Converter) circuit. The DAC statement is used to assign an output level to each DAC channel. Each DAC channel can be set up for a variety of output voltage and current ranges, such as 0 to 10 volts, -10 to 10 volts, 4 to 20 mA, etc. This means that the actual output supplied by a particular DAC statement value depends upon the configuration of the analog output module. For instance, if DAC channel 3 jumpers are set for 0 to 10 volt operation, and the statement DAC 3,300 is executed, the output from channel 3 will be 10*300/1023 volts, or 2.93 volts.

UCP: On the UCP, the *value* argument is a number between 0 and 32767, corresponding to 0 to 10 volts.

Example:

```
100  ' Program to output a sine wave on DAC channel 1.
110  INTEGER J,Y
120  FOR J=0 TO 628                        ' Go through an entire cycle.
130    Y=1023.0*SIN(J/100.0)               ' Scale sine to fit Boss DAC range.
135    Y=32767.0*SIN(J/100.0)              ' Scale sine to fit UCP DAC range.
140    DAC 1,Y                             ' Output the value.
150  NEXT J
160  GOTO 120                              ' Loop forever.
```

Notice that in line 130, the constants (1023.0 and 100.0) are given as real numbers (with a decimal point). By doing this, the program runs slightly faster, since the compiler doesn't have to convert the numbers from integer to real each time that the line is executed.

Related topics:

ADC, Chapter 7, Appendix H

DATA Statement

Summary:

The DATA statement defines constant values to be accessed with READ statements.

Syntax:

DATA *data_list*

Arguments:

data_list list of constant values separated by commas. The values may be numeric or string. Strings must be surrounded by double quotes, and may contain commas, colons, spaces, and other punctuation.

Description:

DATA statements are used to define a block of constants which will be read by READ statements. All DATA statements must be in the program before the first READ statement; when the first READ statement is encountered, BASIC searches for all DATA statements. While the program is executing, each READ statement accesses the next DATA element in order; the DATA elements are treated as a continuous list of items, regardless of how they are arranged into statements. The variable type given in the READ statement must agree with the corresponding constant in the DATA statement.

Example:

```
100  INTEGER J,K
110  REAL X
120  STRING A$
130  PRINT "DATA statement example"
140  ' Data table for program
150  DATA 4.77,2,3,4,5,23,83,8            ' Must be before first READ
160  DATA 999,3.14159,1.6667
170  DATA 893.664,999,"Data 1"
180  DATA "This is a test: Hi, everybody"
190  FOR J=1 TO 3
200    READ K: PRINT K                     ' Print first 3 elements
210  NEXT J
220  READ J
230  IF J<>999 THEN PRINT J: GOTO 220     ' Print elements until a 999
240  READ X
250  IF X<999.0 THEN PRINT X: GOTO 240    ' Print elements until a 999
260  READ A$: PRINT A$                     ' Print first string
270  READ A$: PRINT A$                     ' Print second string
280  READ X: PRINT X                       ' Wrap around, do first one again
```

This produces the following output when run:

```
DATA statement example
4
2
3
4
5
23
```

```
83
8
3.14159
1.66670
893.66381
Data 1
This is a test: Hi,
4.77000
```

The two 999 values in lines 160 and 170 are used as flags to indicate the end of portions of the table; this makes it easy to add to the DATA table without needing to change the program where the READ statements are executed. In line 270, it prints "This is a test: Hi, " because the string variable A$ defaults to 20 character maximum length, so it truncates the rest of the string when it is read. Note that in line 280, it reads beyond the end of the DATA table, so it wraps around and reads the first value in the table.

Related topics:

READ, RESTORE

DEF Statement

Summary:

The DEF statement marks the beginning of a user defined function.

Syntax:

DEF *funcname*, [*arg1*] [,*arg2*]...

Arguments:

funcname a string constant. The name to use for the function that will be defined on the following lines; this must follow the rules for variable names.

argx a numeric or string expression. An argument to be passed to the function.

Description:

The DEF statement marks the beginning of a user defined function.

Example:

Related topics:

FNEND, Chapter 3

DEFMAP Statement

Summary:

The DEFMAP statement provides access to memory outside of the normal area accessible by a BASIC program.

Syntax:

DEFMAP *addr*

Arguments:

addr an integer expression. The high order 8 bits of a 20 bit address. This is set to -1 to access the normal 64KB BASIC program area; this is the default value when a program starts executing.

Description:

Bear BASIC normally provides a 64KB area for the compiled program to execute in; all of the code and data for a program reside in this area. The actual address space accessible to the processor is 1MB, however. DEFMAP allows PEEK, WPEEK, POKE, and WPOKE to access any address in the 1MB physical address space. Only some address areas contain memory that may be accessed by the user; caution must be exercised when using the DEFMAP statement. The DEFMAP value is global to all tasks; be careful when using DEFMAP in more than one task.

The PEEK and POKE statements calculate the address to access as follows:

addr = D_ADDR * $1000 + P_ADDR AND $0FFF,

where D_ADDR is the DEFMAP address and P_ADDR is the PEEK or POKE address. When a BASIC program starts execution, the D_ADDR value is set to -1, which causes all PEEK and POKE commands to access the normal 64K area. When DEFMAP is executed with any value other than -1, the D_ADDR is set to that value, and all succeeding PEEK and POKE commands access addresses that are in a 4KB block somewhere in the 1MB address space. For instance, to access physical address $20123, the program must perform a DEFMAP $20, followed by a PEEK($123). Note that when using DEFMAP with a value other than -1, the PEEK/POKE address is truncated to 12 bits (ie. ANDed with $0FFF). If the DEFMAP address is set back to -1, then the PEEK/POKE address translation is disabled, and all 16 bits are used to specify a logical address in the normal 64K BASIC area.

Example:

```
100  INTEGER X,Y,M,C
110  STRING A$(20), B$(1)
120  FOR X=0 TO 7                    ' Display 8 4K blocks of memory
130  M=$20 + X                       ' Display starting at $20
140  DEFMAP M                        ' Set memory mapping base address
150  C=0: A$=""
160  FOR Y=0 TO $FFF                 ' Do a 4K block
170  IF C = 0 THEN  PRINT: FPRINT "H2H3X4Z",M,Y ' Display address
180  FPRINT "H2X1Z",PEEK(Y)          ' Display hex value
190  B$="."                          ' Default to period character
```

```
200  IF PEEK(Y)>31 AND PEEK(Y)<$7F THEN B$=CHR$(PEEK(Y))
210  A$ = CONCAT$(A$,B$)            ' Build string of characters to display
220  C=C + 1                        ' Increment character counter for line
230  IF C = 16 THEN  PRINT A$; : C=0: A$=""     ' Finish this line
240  NEXT Y
250  NEXT X
260  PRINT
```

This example displays the contents of memory as hexadecimal values and ASCII characters (a "memory dump" in computer terminology). It displays 32 KB of memory starting at $20000; change line 120 to set the number of 4 KB blocks to display, and change line 130 to set the starting address. The Boss Bear stores the source code for the user's BASIC program starting at $20000, so this program will show how Bear BASIC stores a program. Here is a sample of the program's output:

```
20000    64 00 42 3A 3A 11 BD F0 00 00 2C F0 01 00 2C F0 d.B:.....,...,.
20010    02 00 2C F0 03 00 3A 00 6E 00 3D 31 3A 10 C2 F1 ..,...:.n.=1:...
20020    04 00 28 32 30 29 2C F1 05 00 28 31 29 3A 00 78 ..(20),...(1):.x
20030    00 00 3D 3A 0C B0 F0 00 00 3D 30 20 54 4F 20 37 ..=:.....=0 TO 7
20040    3A 20 B6 20 44 69 73 70 6C 61 79 20 38 20 34 4B : . Display 8 4K
20050    20 62 6C 6F 63 6B 73 20 6F 66 20 6D 65 6D 6F 72  blocks of memor
20060    79 3A 00 82 00 F0 3A 3A 0D CA F0 02 00 3D 24 32 y:....:.....=$2
20070    30 82 F0 00 00 3A 1A B6 20 44 69 73 70 6C 61 79 0....:.. Display
20080    20 73 74 61 72 74 69 6E 67 20 61 74 20 24 32 30  starting at $20
20090    3A 00 8C 00 0D B2 3A 05 E9 F0 02 00 3A 22 B6 20 :.....:.....:".
200A0    53 65 74 20 6D 65 6D 6F 72 79 20 6D 61 70 70 69 Set memory mappi
200B0    6E 67 20 62 61 73 65 20 61 64 64 72 65 73 73 3A ng base address:
200C0    00 96 00 32 58 3A 07 CA F0 03 00 3D 30 3A 08 CA ...2X:.....=0:..
200D0    F1 04 00 3D 22 22 3A 00 A0 00 00 3D 3A 0F B0 F0 ...="":....=:...
200E0    01 00 3D 30 20 54 4F 20 24 46 46 46 3A 10 B6 20 ..=0 TO $FFF:..
200F0    44 6F 20 61 20 34 4B 20 62 6C 6F 63 6B 3A 00 AA Do a 4K block:..
20100    00 20 3A 3A 0D B2 F0 03 00 87 30 20 54 48 45 4E . ::......0 THEN
20110    20 3A 02 B8 3A 13 BA 22 48 32 48 33 58 34 5A 22  :..:.."H2H3X4Z"
20120    2C F0 02 00 2C F0 01 00 3A 12 B6 20 44 69 73 70 ,...,...:.. Disp
20130    6C 61 79 20 61 64 64 72 65 73 73 3A 00 B4 00 03 lay address:....
```

Related topics:

POKE, PEEK, WPOKE, WPEEK, Memory Map

DIN Function

Summary:

The DIN (Digital INput) function reads input expander modules attached to the Boss Bear.

Syntax:

x = DIN (*addr*)

Arguments:

addr an integer expression. The address of the input channel to read.

Description:

One or more Divelbiss I/O expander boards can be attached to the Boss Bear; DIN is used to read the input modules. It returns an INTEGER value; a 0 if the input is off, or a 1 if the input is on. *addr* is the input address to read; it will be a number between 0 and 127 ($00 and $7F).

DIN can also be used to read the current keypad status; for example, so that one of the keypad buttons can be used as a "jog" button. The keypad is accessed when *addr* is 256 ($100); the INTEGER returned is the key number (same thing returned by KEY). When the KEY function is used to read the keypad, it has an autorepeat delay which makes it hard to determine how long a button has been pressed. DIN just returns the status of the keypad at the current time, disregarding the autorepeat logic. DIN reads the keypad regardless of what the current FILE is, unlike KEY, which only reads the keypad if a FILE 6 statement has been executed.

Examples:

```
100  ' Program to read all 16 inputs on I/O page 3.
110  INTEGER J,K
120  FOR J=$30 TO $3F
130    K=DIN(J)
140    PRINT J,K
150  NEXT J

100  ' Program to display the current keypad status.
110  INTEGER J
120  LOCATE 1,1
130  FPRINT "I3Z", DIN($100)
140  GOTO 120
```

Related topics:

DOUT, BBOUT, BBIN, Chapter 7, KEY, Chapter 5

DIR Direct Command

Summary:

The DIR direct command displays a list of files contained on the user's EPROM.

Syntax:

DIR

Arguments:

DIR needs no arguments.

Description:

DIR displays a list of files stored on the EPROM that is currently in the EPROM programming socket. It displays the file name, file number (files are numbered sequentially), file type (source or code), and file size (truncated to the nearest KB). It also displays the amount of free space on the EPROM, truncated to the nearest KB.

Example:

Related topics:

LOAD, SAVE

DOUT Statement

Summary:

The DOUT (Digital OUTput) statement controls output expander modules attached to the Boss Bear.

Syntax:

DOUT *addr*, *state*

Arguments:

addr an integer expression between 0 and 127. The address of the output channel to turn off or on.

state an integer expression. A value of 0 turns the output off; any other value turns the output on.

Description:

One or more Divelbiss I/O expander boards can be attached to the Boss Bear; DOUT is used to control output modules.

Example:

```
100  ' Program to turn all 16 outputs on I/O page 2 off, then delay
110  ' for 2 seconds, then turn them on.
120  INTEGER J,K
130  FOR J=0 TO 1             ' Turn outputs off, then on
140    FOR K=$20 TO $2F       ' Access all outputs on I/O page 2
150      DOUT K,J
160    NEXT K
170    WAIT 200
180  NEXT J
```

Related topics:

DIN, BBOUT, BBIN

DOWNLOAD Direct Command

Summary:

The DOWNLOAD direct command disables echoing to the serial port to provide for more reliable program downloading.

Syntax:

DOWNLOAD

Arguments:

DOWNLOAD needs no arguments.

Description:

Normally, the Boss Bear echoes all characters entered at the command line prompt back to the terminal, to allow the user to see what is being typed. When downloading a program, however, this causes errors to be scrolled off of the screen. The DOWNLOAD command solves this by disabling the console echo until either an END command or a CTRL-Z is received; any errors that are encountered are still displayed. After the END or CTRL-Z is received, the message Warning: duplicate line numbers detected is displayed if two lines were entered with the same line number; this may or may not be a problem, depending upon the programmer's style.

The easiest way to use DOWNLOAD is to put the DOWNLOAD command as the first line in the file containing the BASIC program (don't put a line number in front of DOWNLOAD) and put END as the last line in the file (again, with no line number). Then, when the file is sent to the Boss Bear, only error messages will be displayed. Many editors put a CTRL-Z at the end of files; if this is the case, then the END does not need to be entered into the file, since DOWNLOAD will enable echoing again when it sees the CTRL-Z.

Another advantage of using DOWNLOAD is that the file transfer to the Boss Bear will be faster, since the Boss Bear must use processor time to echo the characters back.

Note that if an error is detected while downloading a file, the Boss Bear may miss some characters while it is printing the error message, which will cause other errors to be displayed that aren't actually valid.

Example:

The following shows how to create a file that will download as described above.

```
DOWNLOAD
100  ' This is the BASIC program to be downloaded
110  PRINT "This is a BASIC program"
END
```

EDIT Direct Command

Summary:

The EDIT direct command allows the programmer to modify the BASIC source code.

Syntax:

EDIT *linenum*
or
E *linenum*

Arguments:

linenum a valid BASIC line number. The number of the line to be modified.

Description:

EDIT invokes the Bear Basic line editor. The line is displayed with the cursor positioned at the first character. The following function keys can be used:

Control S - Move the cursor left one position.
Control D - Move the cursor right one position.
Control G - Delete the character at the cursor.
Backspace - Delete the character one space to the left of the cursor.
Control A - Beginning of Line.
Control F - End of Line.
Control V - Toggle insert mode on and off.

If insert mode is off, any character entered will replace the character at the cursor and will move the cursor to the right one space. If insert mode is on, any character entered will be added at the cursor position, causing the entire line at the cursor and to the right of the cursor to move right one space. A carriage return will cause the modified line to be sent to the compiler. The editor will only work with a line short enough to fit on a single 80 character line.

Note that EDIT will not work correctly unless the console terminal is set up to emulate an ADM-3A or ADM-5 terminal type.

EEPEEK Function

Summary:

The EEPEEK function returns the value stored at the specified address in the EEPROM memory.

Syntax:

x = EEPEEK (*addr*)

Arguments:

addr an integer expression between 0 and 991 (for the 2K EEPROM), between 0 and 4063 (for the 8K EEPROM), or between 0 and 223 (for the UCP). The address to be read from.

Description:

The Boss Bear can be purchased with an optional EEPROM memory device installed; this can be either a 2KB or 8KB device. The EEPEEK function operates in a similar fashion to the WPEEK function, except that it reads from the EEPROM instead of from the RAM. EEPEEK returns the INTEGER value stored at *addr* in the EEPROM; note that the address is specified as an offset from the beginning of the EEPROM. Unlike the EEPOKE statement, EEPEEK can be performed an unlimited number of times, and it operates very quickly (approximately 40 microseconds). The EEPROM can also be read by performing a DEFMAP $60 followed by a PEEK or WPEEK; this technique should be avoided, however, because the timing used by the EEPEEK is matched to the EEPROM, which may be slower than the RAM. The EEPEEK statement takes about 100 microseconds to execute.

To store real variables in the EEPROM, the variable must be stored using two EEPOKEs and retrieved using two EEPEEKs. The second example demonstrates this.

UCP: The UCP uses a Touch Memory device for non-volatile storage. This device cannot be accessed using DEFMAP, as described above for the Boss Bear's EEPROM. The EEPEEK statement on the UCP takes about 150 milliseconds to execute, which is much slower than the Boss Bear.

Examples:

```
100  ' Program to read the first 20 values from EEPROM.
110  INTEGER J,K
120  FOR J=0 to 19
130    K=EEPEEK(J)
140    PRINT J,K
150  NEXT J
```

```
100  REAL X,Y,HOLD,HOLD2
110  INTEGER FIRST,SECOND
120  X=3.45
130  FIRST=WPEEK(ADR(X))
140  SECOND=WPEEK(ADR(X)+2)
150  EEPOKE 10,FIRST
160  EEPOKE 11,SECOND
180  HOLD=EEPEEK(10)
190  HOLD2=EEPEEK(11)
192  WPOKE ADR(Y),HOLD
194  WPOKE ADR(Y)+2,HOLD2
200  PRINT"Value of Y is":Y
300  PRINT"Value of 10=";:PRINT EEPEEK(10)
```

Related topics:

EEPOKE, PEEK, POKE, WPEEK, WPOKE, APPENDIX H

EEPOKE Statement

Summary:

The EEPOKE statement stores a value at the specified address in the EEPROM memory. Note that this statement takes approximately 20 milliseconds to return. Also, each byte of the EEPROM can only be written to approximately 10,000 times before the byte fails.

Syntax:

EEPOKE *addr*, *value*

Arguments:

addr	an integer expression between 0 and 991 (for the 2K EEPROM), between 0 and 4063 (for the 8K EEPROM), or between 0 and 223 (for the UCP). The address to be written to.
value	an integer expression. The value to write into the EEPROM.

Description:

The Boss Bear can be purchased with an optional EEPROM memory device installed; this can be either a 2KB or 8KB device. The EEPOKE statement operates in a similar fashion to the WPOKE statement, except that it writes to the EEPROM instead of to the RAM. EEPOKE stores the INTEGER *value* at *addr* in the EEPROM; note that the address is specified as an offset from the beginning of the EEPROM. Remember that, due to the characteristics of EEPROM technology, each byte in the EEPROM can only be written to approximately 10,000 times before failing; if the value to be written matches the value already stored at that location, then EEPOKE won't perform the write operation, so that it doesn't waste one of the 10,000 write cycles. Note also that it takes about 20 msec for this statement to return, since EEPROMs write each byte in about 10 msec. The EEPROM can also be written to by performing a DEFMAP $60 followed by a POKE or WPOKE; this technique should be avoided, however, because EEPOKE handles the 20 msec delay required by the EEPROM, whereas POKE and WPOKE do not take this delay into account.

See EEPEEK for an example demonstrating how to store real numbers in the EEPROM.

UCP: The UCP uses a Touch Memory device for non-volatile storage. There are no limitations on the number of times that data can be written to this device. The EEPOKE statement takes about 150 msec on the UCP.

Example:

```
100  ' Program to write 20 values into EEPROM.
110  INTEGER J,K
120  FOR J=0 to 19
130    K=J*3+7
140    EEPOKE J,K
150  NEXT J
```

Related topics:

EEPOKE, PEEK, POKE, WPEEK, WPOKE, Appendix H

EPROM LOAD Direct Command

Summary:

The EPROM LOAD direct command loads a BASIC program from the user's EPROM.

Syntax:

EPROM LOAD [*filenum*]

Arguments:

filenum an integer number from 1 through the number of files stored on the EPROM. The number of the file to load.

Description:

If *filenum* is specified, then EPROM LOAD loads source file number *filenum* from the EPROM, otherwise, it loads the last source file from the EPROM. EPROM LOAD is identical to LOAD.

Example:

`EPROM LOAD`	Loads the last source file.
`EPROM LOAD 3`	Loads the third source file.

Related topics:

EPROM SAVE, LOAD, SAVE

EPROM SAVE Direct Command

Summary:

The EPROM SAVE direct command saves the BASIC source or compiled code that is in memory to the user's EPROM.

Syntax:

EPROM SAVE [CODE] [*filename*]

Arguments:

filename a text string, up to 10 characters long. The filename to be stored on the EPROM. The name will be stored in uppercase, even if it is entered in lowercase.

Description:

EPROM SAVE stores the current BASIC source program onto the user's EPROM. EPROM SAVE CODE stores the current compiled code onto the user's EPROM. If *filename* is specified, then it is stored with the file. The file name for a source program is just used as a comment, to indicate what the program does. With compiled code, however, the file's name can be used with the CHAIN statement. It is possible to have more than one file on an EPROM with the same name; these files will be differentiated by their file numbers.

Example:

`EPROM SAVE`	Saves the BASIC source with no filename.
`EPROM SAVE CODE`	Saves compiled code with no filename.
`EPROM SAVE Program1`	Saves the BASIC source as PROGRAM1.
`EPROM SAVE CODE test`	Saves compiled code as TEST.

Related topics:

EPROM LOAD, SAVE, LOAD

ERASE Statement

Summary:
The ERASE statement erases the current display device.

Syntax:
ERASE

Arguments:
ERASE needs no arguments

Description:
ERASE sends the clear-screen command to the currently active FILE. It works for the console terminal (FILE 0) and the front panel display (FILE 6, which can be either LCD or VFD). Note that in order for this to work correctly with FILE 0, the terminal must be set to emulate an ADM3 or ADM5 terminal.

Example:
```
100  INTEGER J
110  FOR J = 1 TO 1000
120    FILE 0: PRINT "*";
130    FILE 6: PRINT "*";
140  NEXT J
150  WAIT 100
160  CLS
170  FILE 0: ERASE
```

Related topics:
CLS

ERR Function

Summary:

The ERR function returns the number corresponding to the last error that was detected.

Syntax:

x = ERR

Arguments:

ERR needs no arguments.

Description:

Bear BASIC detects two kinds of errors at runtime: I/O errors and program errors. An I/O error indicates that an I/O device reported an error during a transfer; this happens most often with serial data transfer. A program error indicates that a serious program error was detected, such as `Return Without Gosub` or `Subscript Out of Range`. The ERR function returns the integer number that corresponds to the most recently detected error:

0	$0	No error
1	$1	Serial transmission timeout
2	$2	Failure programming EEPROM
16	$10	COM1 receive error (overrun, parity, framing)
17	$11	COM2 receive error (overrun, parity, framing)
256	$100	Undefined error
263	$107	Expression Error
264	$108	String Variable Error
266	$10A	Line Number Does Not Exist
267	$10B	Task Error
271	$10F	RETURN Without GOSUB
272	$110	Subscript out of Range
273	$111	Overflow
275	$113	Task Mismatch
276	$114	Function Error
277	$115	String Length Exceeded
280	$118	Illegal Print/Input Format
281	$119	String Space Exceeded
282	$11A	Illegal File Number
283	$11B	Improper Data to INPUT Statement
285	$11D	Data Statement Does Not Match Read
286	$11E	Failure Programming EPROM or EEPROM

The error numbers greater than 255 ($FF) are fatal program errors that will cause the program execution to stop; they can be trapped using JVECTOR and address $13 to jump to a task when a fatal error occurs (see JVECTOR). The error numbers up to 255 ($FF)

are nonfatal I/O errors that can be handled with the ON ERROR statement or by checking the ERR function periodically.

Note that when ERR is referenced, it returns the most recent I/O error detected and resets the I/O error to 0. This means that an error on one device could overwrite an error on another device if ERR isn't checked often enough. It also means that the ERR value must be read into another variable if it will be needed again (see the example below). A successful I/O operation won't reset the I/O error value to 0; if a character is received on COM1 with a parity error and then other characters are received successfully, when ERR is checked it will return 16 to indicate that a receive error occurred on COM1.

Example:

```
100  INTEGER J,K
110  K=KEY
120  IF K<>0 THEN PRINT CHR$(K);
130  J=ERR
140  IF J<>0 THEN FILE 6: PRINT "Error ";J: FILE 0
150  GOTO 110
```

Run this example with the terminal set to 9600 bps, even parity, 8 data bits, and 1 stop bit. Some of the ASCII characters sent to the Boss Bear will generate an error 16, because those characters will cause a framing error when received by the Boss Bear, which is using 9600 bps, no parity, 8 data bits, and 1 stop bit. The value of ERR is stored in the variable J in line 130 because it may be needed twice in line 140. If line 130 were removed and J in line 140 were replaced with ERR, then it would always print "Error 0", because the first reference to ERR would set the error status back to 0.

Related topics:

ON ERROR, JVECTOR, Chapter 11

ERROR Direct Command

Summary:
The ERROR direct command enables error checking in the compiled BASIC program.

Syntax:
ERROR

Arguments:
ERROR needs no arguments.

Description:
ERROR turns on the compiler's runtime error checking software. It is the converse of NOERR. When Bear BASIC is first started, all runtime error checking is on. It stays on until explicitly disabled by NOERR. Runtime error checking is essential in most programs to insure that mistakes don't "blow up" the compiler. For example, if a "SUBSCRIPT OUT OF RANGE" error were not detected, a program could write over itself, causing unpredictable and undesirable results.

Like NOERR, ERROR modifies the code generated during compilation of the program, so it must be specified before the program is RUN or COMPILEd (if you have used NOERR in the Bear BASIC session before RUN or COMPILE). ERROR will then remain in effect unless disabled by NOERR or NEW.

Unfortunately, the runtime error checking software makes the compiled code larger and slower. If code size and speed are important, then the program should be compiled with NOERR enabled after it has been debugged.

Related topics:
NOERR

EXIT Statement

Summary:

The EXIT statement causes the currently executing task to abort. When the schedule interval specified in the RUN statement has elapsed, the task will be started at its beginning.

Syntax:

EXIT

Arguments:

EXIT needs no arguments

Description:

EXIT causes the currently executing task to abort. When the EXIT is encountered, the task stops until the schedule interval specified in the RUN statement elapses, at which point the task starts over again from its beginning. Note that EXIT does not stop the task from being rescheduled; only CANCEL can do that. Whenever EXIT is executed, it automatically turns interrupts back on (ie. simulates an INTON). This feature is needed by hardware device interrupt handlers to insure that the device interrupt handler can return just as interrupts are re-enabled.

Example:

```
100  INTEGER J,K
110  PRINT "Press any key to stop"
120  J=0: RUN 1,100                        ' Start task 1 with 1 sec reschedule.
130  K=GET                                 ' Wait for a key.
140  CANCEL 1                              ' Cancel task 1.
150  PRINT "Wait 2 seconds": WAIT 200      ' Wait for it to stop.
160  STOP                                  ' Halt the program.
200  TASK 1
210  PRINT J;
220  J=J+1
230  WAIT 50                               ' Wait for .5 seconds.
240  PRINT "*";CHR$(13);                   ' Stay on same line - print CR.
250  EXIT                                  ' Abort task, go get rescheduled.
```

Related topics:

RUN, CANCEL, STOP, Chapter 5

EXMOD Statement

Summary:

The EXMOD statement is used to communicate with any of the intelligent expander modules.

Syntax:

EXMOD *port*, *st$* [, *numbytes*]

Arguments:

port	expansion port number. 3, 4, or 5 corresponding to J3, J4, or J5.
st$	string containing data to transfer to the module. If we are reading from the module, then the return data will be passed back in this string, also.
numbytes	this parameter is only specified when reading from the module. It is the number of bytes to be returned back from the module.

Description:

Some of the Divelbiss I/O expander modules are classed as intelligent expanders, which means that they are a complete microprocessor system that acts as a slave processor to the Boss Bear. These modules offload complex I/O processing tasks from the Boss Bear's processor, allowing faster system throughput and better I/O timing accuracy. Since these modules are custom-programmed to perform their specified task, the commands and parameters for each module are unique. The EXMOD statement performs the communications between the Boss Bear's processor and the module's processor. The exact form of this communications depends on the module being used; refer to the module's data sheet to find detailed information.

EXMOD writes a command (stored in *st$*) to the module plugged into the expansion connector referred to by *port*. If the command causes a response from the module, then EXMOD reads *numbytes* of data from the module, which is then returned in *st$*. This is not currently being implemented on the UCP.

Example:

```
100  ' Example to show EXMOD communicating with stepper module.
110  INTEGER PORT,CHNL: STRING EX$(10)
200  PORT=4: CHNL=1                          ' Module in J4, stepper channel 1
300  ' Set acceleration and deceleration rates for channel 1.
310  EX$=CONCAT$(CHR$($83),CHR$(CHNL))       ' Command $83 and channel number
320  EX$=CONCAT$(EX$,MKI$(2000))             ' Accel rate = 2000 pulse/second
330  EX$=CONCAT$(EX$,MKI$(1500))             ' Decel rate = 1500 pulse/second
340  EXMOD PORT,EX$                          ' Send data to module
400  ' Read status back from stepper module.
410  EX$=CONCAT$(CHR$($84),CHR$(CHNL))       ' Command $84 and channel number
420  EXMOD PORT,EX$,7                        ' Read status from module (7 bytes)
430  FPRINT "H2",ASC(EX$)                    ' Display module mode in hexadecimal
440  PRINT CVI(MID$(EX$,2,2))                ' Display low word of step count
450  PRINT CVI(MID$(EX$,6,2))                ' Display current pulse rate
```

Related topics:

Chapter 9

EXP Function

Summary:

The EXP function calculates the exponential function.

Syntax:

x = EXP (*expr*)

Arguments:

expr a numeric expression.

Description:

The EXP function returns e^{expr}, which must be a numeric expression. The result is returned as a REAL value. This is the converse of the natural logarithm function (LOG).

By using the properties of logarithms, a number X can be raised to a power Y (X^Y) using `EXP(LOG(X)*Y).`

Example:

```
100  REAL X,Y
110  PRINT EXP(0.35)
120  X=-1.82
130  Y=EXP(X)
140  PRINT "Exp value of ";X;" is ";Y
150  PRINT "4 cubed = "; EXP(LOG(4)*3)
```

This produces the following output when run:

```
1.41834
Exp value of -1.82000 is .16171
4 cubed = 64.00003
```

Related topics:

LOG, LOG10

EXPMEM Statement

Summary:

The EXPMEM statement stores and retrieves memory form the expanded memory board on the UCP.

Syntax:

EXPMEM *read/write, vartype, block, reg_number, variable, status*

Arguments:

read/write	an integer value of 0 or 1. This indicates what type of memory transfer: 0 for READ, or 1 for WRITE.
vartype	an integer value of 0, 1, or 2. This indicates the type of variable to use: 0 for INTEGER, 1 for REAL, 2 for STRING.
block	an integer expression of 0, 1, 2, or 3. This value specifies which memory block to use.
reg_number	an integer expression from 0 to 65535. This value specifies which memory register to use.
variable	The value to be used in the memory transfer. The type depends on the *vartype* argument.
status	an integer expression. This will hold the status of the operation; a 0 will indicate a successful operation, while a nonzero value will indicate that an error occurred.

Description:

The **EXPMEM** statement is used to save and retrieve values stored in the optional expanded memory board on the UCP. The expanded memory board hold an additional 512K of battery backed memory to store large amounts of data. The memory is divided up into four blocks of 128K. Each INTEGER uses 2 bytes, each REAL uses 4 bytes, and each STRING uses 32 bytes thus allowing each block to hold 65536 INTEGERs or 32768 REALs or 2048 STRINGs. Caution must be taken to not to use more than one variable type in a single block. STRINGs must be defined as 32 bytes long when using the **EXPMEM** statement. When reading a STRING from the expanded memory, a 32 byte STRING is always returned, regardless of what had been stored.

Example:

```
100  INTEGER A,B,C,D,E,F
110  REAL H,I
```

```
120  ' make sure that the strings are 32 bytes long
130  STRING J$,K$(32),L$(32)
140  K$="01234567890123456789012345678901"  ' initialize the string
150  J$="ok":C=0:A=0
160  PRINT "start"

200  FOR B=0 TO 2047                        ' loop for 2048 springs
210  EXPMEM 1,2,A,B,K$,D                    ' store string K$ at register B
220  IF D <> 0 THEN ?"STATUS ERROR":STOP    ' check for error
230  EXPMEM 0,2,A,B,L$,D                    ' read the string into L$
240  IF D <> 0 THEN ?"STATUS ERROR":STOP    ' check for error
250  IF K$ <> L$ THEN  J$="problem":C=C+1   ' make sure they are the same
260  L$=" "
270  NEXT B
280  PRINT J$;" ";C;" ERRORS ACCRUED"       ' show errors if any
290  PRINT "block 0 finished":J$="ok":C=0:A=1

300  FOR B=0 TO 32767                       ' loop for 32768 reals
310  I=0:H=B
320  EXPMEM 1,1,A,B,H,D                     ' store in block 1 register B
330  IF D <> 0 THEN ?"STATUS ERROR":STOP    ' check for error
340  EXPMEM 0,1,A,B,I,D                     ' read the real into F
350  IF D <> 0 THEN ?"STATUS ERROR":STOP    ' check for error
360  IF H <> I THEN  J$="problem":C=C+1     ' make sure they are the same
370  NEXT B
380  PRINT J$;" ";C;" ERRORS ACCRUED"       ' show errors if any
390  PRINT "block 1 finished":J$="ok":C=0:A=2

400  FOR E=1 TO 2                           ' must make the loop bigger
410  FOR B=0 TO 32767                       ' loop for 65536 integers
420  EXPMEM 1,0,A,B*E,B,D                   ' store in block 2 register B*E
430  IF D <> 0 THEN ?"STATUS ERROR":STOP    ' check for error
440  EXPMEM 0,0,A,B*E,F,D                   ' read the integer into F
450  IF D <> 0 THEN ?"STATUS ERROR":STOP    ' check for error
460  IF F <> B THEN  J$="problem":C=C+1     ' make sure they are the same
470  NEXT B
480  NEXT E
490  PRINT J$;" ";C;" ERRORS ACCRUED"       ' show errors if any
500  PRINT "block 2 finished"

510  PRINT "finished"
```

This program writes STRINGs into block 0, REALs into block 1, and INTEGERs into block 2, checking the values as there written.

Related topics:

FILE Statement

Summary:

The FILE statement causes all subsequent character I/O to be performed with the specified device.

Syntax:

FILE *fnum*

Arguments:

fnum an integer expression. The file number to access; one of the following:

0	COM1 serial port (the "console" port)
1	future expansion
2	future expansion
3	future expansion
4	future expansion
5	COM2 serial port
6	onboard display and keypad
7	future expansion

Description:

The FILE statement causes all subsequent I/O from PRINT, FPRINT, INPUT, INPUT$, FINPUT, GET, KEY, LOCATE, and GOTOXY to be performed with the specified device. It sets the file number for the task that issues the statement; each task maintains its own current file number. The file number for each task defaults to file 0, not to the file number used in the preceding task.

Example:

```
100  PRINT "This is task 0"              ' Output to console (COM1).
110  RUN 1,100: RUN 2,250: RUN 3,325
120  WAIT 1000: STOP                     ' Allow tasks to run a few times.
200  TASK 1
210  FILE 5                              ' Output to COM2
220  PRINT "This is task 1": EXIT
300  TASK 2
310  FILE 6                              ' Output to onboard display.
320  PRINT "This is task 2": EXIT
400  TASK 3
410  PRINT "This is task 3"              ' Output to console (COM1).
420  FILE 6                              ' Also to onboard display.
430  PRINT "Also task 3": EXIT
```

Related topics:

PRINT, FPRINT, INPUT, INPUT$, FINPUT, KEY, GET, LOCATE, GOTOXY, CLS

FINPUT Statement

Summary:

The FINPUT statement provides a simple way to get numeric entry from the user.

Syntax:

FINPUT *format*, *variable*

Arguments:

format a string expression. This defines the format of the number to get from the user. The following are valid:

Ux	unsigned integer, where x is the number of digits allowed.
Ix	signed integer, where x is the number of digits allowed, not including the minus sign (ie. "I2" will allow the user to type -23).
Fx.y	real, where x is the number of digits to the left of the decimal point, and y is the number to the right.

variable integer or real variable name. The value entered will be put into this variable.

Description:

FINPUT provides a simpler way to get numeric input from the user. It will only accept entries that follow the specified format; the user will not be allowed to deviate from this format. For example, if a 2 digit product code must be entered, the statement `FINPUT "I2", PRDCOD` will only allow 2 digits to be entered. If the user presses backspace (when using a terminal with FILE 0 or 5) or CLEAR (when using the built in keypad) after entering some digits, then these digits will be erased and the user can start again; the cursor will be at its original starting position. If the format string does not follow the form recognized by Bear BASIC, then FINPUT will instantly return zero, without waiting for input from the user.

FINPUT should not be used in an interrupt task, because it re-enables interrupts and allows multitasking to continue. Depending upon what the other tasks are doing at the instant that the interrupt task executes, FINPUT could cause the system to lock up.

Example:

```
100  INTEGER J
110  REAL X
120  CLS: LOCATE 10,1
140  PRINT "Enter product number (0-99) >    ";
150  LOCATE 10, 31: FINPUT "I2", J
160  LOCATE 12,1
170  PRINT "Enter temperature setpoint (180.00-209.99) >       ";
180  LOCATE 12,46: FINPUT "F3.2", X
190  IF X < 180.0 OR X >= 210.0 THEN GOTO 160
```

Related topics:

INPUT, FPRINT

FNEND Statement

Summary:

The FNEND statement marks the end of a user defined function.

Syntax:

FNEND

Arguments:

FNEND needs no arguments

Description:

FNEND is used in conjunction with DEF to create a user defined function: DEF marks the beginning of the function, and FNEND marks the end.

Example:

```
100  INTEGER RIGHTN
110  STRING TEST$, RIGHT$(127), RIGHTA$(127)
120  ' This function returns the N rightmost characters of A$.
130  DEF RIGHT$ (RIGHTA$, RIGHTN)
140    RIGHT$=MID$(RIGHTA$, (LEN(RIGHTA$)-RIGHTN+1, RIGHTN)
150  FNEND
160  TEST$="This is a test"
170  PRINT TEST$;" <";RIGHT$ (TEST$, 4);">"
```

This produces the following output when run:

```
This is a test <test>
```

Related topics:

DEF, Chapter 3

FOR Statement

Summary:

The FOR statement is used with the NEXT statement to implement a loop control structure to execute a range of lines multiple times.

Syntax:

FOR *variable* = *expr1* TO *expr2* [STEP *expr3*]

Arguments:

variable an integer or real variable, to be used as the loop counter. This must be a non-subscripted variable.

expr1 a numeric expression. This is the starting value of the loop. *variable* will be set to this value before executing the body of the loop for the first time.

expr2 a numeric expression. This is the ending value of the loop. *variable* is tested against this value after executing the body of the loop; if *variable* is less than *expr2* then the loop will be executed again.

expr3 an optional numeric expression. If specified, this value will be added to *variable* each time through the loop. If this isn't specified, then *variable* will be incremented by 1 each time.

Description:

The FOR..NEXT construct specifies that a series of lines should be executed multiple times in a loop. Program lines following the FOR statement are executed until the NEXT statement is encountered, at which time *variable* is incremented by *expr3*, or by 1 if *expr3* is not specified. If *variable* is less than *expr2*, then BASIC jumps back to the statement immediately following the FOR statement, and this process repeats. If *variable* is greater than or equal to *expr2*, then BASIC continues execution with the statement following the NEXT statement. For example, the statement FOR X=4 TO 13 STEP 2 will cause the loop to be executed 5 times, for 4, 6, 8, 10, and 12.

In order to cause a loop to count downwards, a negative STEP value may be used. If *expr3* is negative, then *variable* will be decremented each time through the loop. For example, the statement `FOR J=10 TO 1 STEP -1` will cause the loop to be executed 10 times, for 10, 9, 8, ..., 1.

Note that the body of the loop is always executed once, because the test *variable<expr2* is performed when NEXT is encountered.

It is possible to alter the value of *variable* inside the body of the loop. Extreme care should be used when doing this, however, as it can result in very subtle problems. In general, *variable* should not be altered, except by the FOR statement itself.

A FOR..NEXT loop may be used inside of another FOR..NEXT loop; this is called a nested loop. Each loop must have a unique variable name in the *variable* field. The inside FOR..NEXT loop must be entirely enclosed in the outer one.

Example:

```
100  INTEGER J,K
110  REAL X,Y
120  FOR J=3 TO 8
130    FOR K=1 TO 7 STEP 2
140      FPRINT "I2I2X2Z", J, K
150    NEXT K: PRINT
160  NEXT J
170  PRINT
180  FOR X=360.0 TO 0.0 STEP -22.5
190    FPRINT "F3.1F7.3", X, SIN(X)
200  NEXT X
```

This produces the following output when run:

```
 3 1   3 3   3 5   3 7
 4 1   4 3   4 5   4 7
 5 1   5 3   5 5   5 7
 6 1   6 3   6 5   6 7
 7 1   7 3   7 5   7 7
 8 1   8 3   8 5   8 7

360.0       .000
337.5      -.383
315.0      -.707
292.5      -.924
270.0     -1.000
247.5      -.924
225.0      -.707
202.5      -.383
180.0       .000
157.5       .383
135.0       .707
112.5       .924
 90.0      1.000
 67.5       .924
 45.0       .707
 22.5       .383
   .0       .000
```

Related topics:

NEXT

FPRINT Statement

Summary:

The FPRINT statement allows formatted printing to the current FILE.

Syntax:

FPRINT *format*, *arg1* [,*arg2*]...

Arguments:

format a string expression. This specifies how the following arguments are to be printed. The following symbols are valid:

Fn.x	prints n digits before the decimal point and x digits following it. Leading zeros are converted to spaces, and trailing zeros are left as zeros. No more than 6 positions following the decimal point are allowed.
Hn	prints n hexadecimal digits. Leading zeros are printed.
In	prints n integer digits. Leading zeros are converted to spaces.
Sn	print n characters of a string. If the string more than n characters long, then the first n characters are printed. If the string is shorter than n characters, then trailing spaces are printed.
Un	print n unsigned integer digits. Leading zeros are converted to spaces.
Xn	prints n spaces.
Z	suppresses the carriage return at the end of the line. This is only legal at the end of the format string.

argx a numeric or string expression. Each argument must match the corresponding entry in the format string.

Description:

FPRINT is a more sophisticated version of the PRINT statement which allows the programmer to control the format of the data output by the program. FPRINT prints each argument in the list of expressions using the corresponding control information from the format string (*format*, above). The type of each expression must match it's corresponding control string in *format*; a runtime error will occur if the types do not match. The specified field widths are strictly enforced; each expression is forced to fit in it's field. If a numeric value is too large to fit in the specified field, then the field is filled with asterisks instead. For example, if a format of "H2" is given, and the number to be output is $123, then "**" will be printed. For a string field, the string is truncated to fit in the specified field.

FPRINT should not be used in an interrupt task, because it re-enables interrupts and allows multitasking to continue. Depending upon what the other tasks are doing at the instant that the interrupt task executes, FPRINT could cause the system to lock up.

Examples:

```
100  INTEGER J, K
110  REAL X
120  J=123: K=$F7: X=38.8746
130  FPRINT "I5X2H4F5.2", J, K, X
```

This produces the following output when run:

```
  123  00F7   38.87
```

Two spaces are printed before the value of J because the field width is set to 5. Two space are printed by the "X2" format in order to separate J and K. Two zeros are printed before the value of K because the field width is set to 4. The fractional part of X is truncated to two digits because the field with is "F5.2".

```
100  INTEGER J
110  STRING A$, B$
120  J=40000
130  FPRINT "I3I7U7", J, J, J
140  A$="Hello": B$="There it is."
150  FPRINT "S5S2S5", A$, ", ", B$
```

This produces the following output when run:

```
*** -25536  40000
Hello, There
```

In this example, it is important to remember that the representation of a number is different than the value of a number; the same numeric value may be represented many different ways. In particular, the hexadecimal number $9C40 can be represented as a signed integer as -25536, or it can be represented as an unsigned integer as 40000. Three asterisks are printed because -25536 won't fit into the 3 digits allowed by the "I3" format. The next line shows how strings are handled; B$ is truncated to the specified 5 characters.

Related topics:

PRINT, FINPUT

FUZZY Statement

Summary:
The FUZZY statement is a control algorithm for use on the UCP.

Syntax:
FUZZY *array address, input 1, input 2, output 1, output 2, status*

Arguments:

array address	an integer value of the address of the first element of the parameter array. The array contains all the mid values, sensitivity values, and rules tables for the FUZZY control algorithm
input 1	an integer expression from -32767 to +32767. This is the first input variable passed to the FUZZY routine.
input 2	an integer expression from -32767 to +32767. This is the second input variable passed to the FUZZY routine.
output 1	an integer expression from -32767 to +32767. This is the first output variable passed from the FUZZY routine.
output 2	an integer expression from -32767 to +32767. This is the second output variable passed from the FUZZY routine.
status	an integer expression. This will hold the status of the operation; a 0 will indicate a successful operation, a 1 indicates output 2 was beyond the range of an integer, a 2 indicates output 1 was beyond the range of an integer, and a 3 indicates both outputs were beyond the range of an integer. When an output is beyond the range of an integer the return value from the FUZZY routine will be +32767 or -32767 depending on the actual sign of the output.

Description:
The **FUZZY** statement supports two inputs, two outputs, seven fuzzy sets with symmetric triangles, user-definable fuzzy set values and a return status. Typical applications include temperature, climate, speed, position, pressure, flow, and fluid depth just to name a few. The statement utilizes a data array which contains 106 integer values which are used by the **FUZZY** statement to generate the outputs. The array address is the first value required by the statement and provides the starting address of all of the data. Inputs 1 and 2 are integer expressions which must be obtained and passed to the statement. In most process control applications both inputs are obtained from the ADC statement which converts an analog input (i.e., speed, pressure, angle, position, temperature, ...) to the UCP into discrete numbers from 0 to 32767. The statement has three return values; output 1, output 2, and status. Outputs 1 and 2 are integer expressions which contain the results of the Fuzzy Logic processing. The status expression will hold the status of the operation; a 0 will

indicate a successful operation, a 1 indicates output 2 was beyond the range of an integer, a 2 indicates output 1 was beyond the range of an integer, and a 3 indicates both outputs were beyond the range of an integer. When an output is beyond the range of an integer the return value from the FUZZY routine will be +32767 or -32767 depending on the actual sign of the output.

As mentioned, the statement requires 106 integer values in order to do the Fuzzy Logic processing. Specifically there are 8 values for fuzzy set mid-points and sensitivities, 49 for the rules for output 1 and 49 rules for output 2 for a total of 106. The data must be contained in a data array in the following order:

input 1 midpoint, input 1 sensitivity
input 2 midpoint, input 2 sensitivity
output 1 midpoint, output 1 sensitivity
output 2 midpoint, output 2 sensitivity

rule output 1 [in1=1, in2=1] ... rule output 1 [in1=1, in2=7]
.
.
rule output 1 [in1=7, in2=1] ... rule output 1 [in1=7, in2=7]

rule output 2 [in1=1, in2=1] ... rule output 2 [in1=1, in2=7]
.
.
rule output 2 [in1=7, in2=1] ... rule output 2 [in1=7, in2=7]

Example:

The following example is for a motor speed control problem with two inputs (speed error and rate of change of speed) and 1 output (change in speed).

```
80    ' Declare variables
100   INTEGER SPDERR, SPDRATE, OUT1, OUT2, ST, DRIVE, FUZLOOP, FUZDAT(106)
110   INTEGER SETPNT, SPD, LASTSPD

115   ' Midpoint and sensitivity data
120   DATA 0,65
140   DATA 0,100
160   DATA 0,320
170   DATA 0,0

175   ' Rules for output 1
180   DATA 7,7,7,7,6,5,4
200   DATA 7,6,6,6,5,4,3
220   DATA 6,6,5,5,4,3,2
240   DATA 5,5,5,4,3,3,3
260   DATA 6,5,4,3,3,2,2
280   DATA 5,4,3,2,2,2,1
300   DATA 4,3,2,1,1,1,1
```

```
310   ' Rules for output 2
320   DATA 0,0,0,0,0,0,0
340   DATA 0,0,0,0,0,0,0
360   DATA 0,0,0,0,0,0,0
380   DATA 0,0,0,0,0,0,0
400   DATA 0,0,0,0,0,0,0
420   DATA 0,0,0,0,0,0,0
440   DATA 0,0,0,0,0,0,0

450   ' Initialize values to zero
460   SPDERR = 0: SPDRATE = 0: LASTSPD = 0: SETPNT = 0: DRIVE = 0

490   ' Read in the fuzzy data into the fuzzy array
500   FOR FUZLOOP = 0 TO 105
520   READ FUZDAT(FUZLOOP)
540   NEXT FUZLOOP

590   ' Setup task 1 to run 10 times a second
600   RUN 1,10

990   ' Infinite loop for the main loop
1000  GOTO 1000

3900  ' Task 1 to read setpoint, speed, calculate input 1 and 2, reserve last
3925  ' speed, use the FUZZY statement, use return value and add to drive,
3950  ' then output the drive.
4000  TASK 1
4020  SETPNT = ADC(1)
4040  SPD = ADC(2)
4060  SPDERR = SPD - SETPNT
4080  SPDRATE = SPD - LASTSPD
4100  LASTSPD = SPD
4120  FUZZY ADR(FUZDAT(0)),SPDERR,SPDRATE,OUT1,OUT2,ST
4140  DRIVE = OUT1 + DRIVE
4150  IF DRIVE < 0 THEN DRIVE = 0
4175  IF DRIVE > 16000 THEN DRIVE = 16000
4160  DAC 1,DRIVE
4180  EXIT
```

The example code above is for a speed control problem. Lines 80 - 110 are for variable declarations. Note that all variables related to the **FUZZY** statement are integers. Lines 115 - 170 contain the data for the midpoints and sensitivities for both inputs and outputs. Lines 175 - 440 contains the rules for output 1 and output 2. Note that although output 2 is not being used in the system the data is still required (all 0's). Lines 490 - 540 demonstrates the easiest way to get the fuzzy data into the data array. Typically this type of setup will make the program easier to read and to modify. Lines 590 and 600 setup the fuzzy control task to break the infinite loop of the main task 10 times per second. Lines 3900 - 4180 contains the fuzzy control task. The first step is to acquire the setpoint which is read in from analog channel 1 using the ADC statement. Next, the current speed is read from analog channel 2. Input 1 (speed error) and input 2 (rate of change of speed) are then calculated for use as inputs to the controller. The current speed is then stored as the last speed for use during the next execution of the task on line 4100. Finally, the **FUZZY** statement is utilized with the array address, inputs 1 and 2, outputs 1 and 2, and the return status. Output 1 is the change in the speed and thus the drive signal is added to the output to obtain the next drive signal (line 4140) which is then limited to ensure valid data. Lastly, the drive signal is output to the motor through D/A channel 1.

FOR MORE DETAILS ON FUZZY LOGIC CONTROL AND USE OF THE FUZZY STATEMENT READ APPENDIX I.

Related topics:

Appendix I

GET Function

Summary:
The GET function returns one character from the current file.

Syntax:
x = GET

Arguments:
GET needs no arguments.

Description:
The GET function reads data from the current file; it waits for the next available character and returns it as an INTEGER value without performing any conversions or filtering. Specifically, unlike INPUT and INPUT$, which treat the carriage return as a delimiter, GET will return the carriage return using it's ASCII value, 13 ($0D). GET waits for the next character to become available. In a multi-tasking program, if there isn't a character available immediately, GET will allow another task to execute, minimizing the processor overhead while waiting; when a character becomes available, GET will return it the next time that the task gets to execute.

GET should not be used in an interrupt task, because it re-enables interrupts and allows multitasking to continue. Depending upon what the other tasks are doing at the instant that the interrupt task executes, GET could cause the system to lock up.

Example:
```
100  ' Program to get keys from the console and the keypad.
110  INTEGER J, K
120  FILE 0: GOSUB 200        ' Read keys from the console.
130  FILE 6: GOSUB 200        ' Read keys from the keypad.
130  STOP
200  ' Subroutine to get 5 characters from the current file and
210  ' echo them back.
220  FOR J = 1 TO 5
230    K=GET
240    PRINT K,CHR$(K)
250  NEXT J
260  RETURN
```

Related topics:
KEY, INPUT, INPUT$, FILE

GETDATE Statement

Summary:

The GETDATE statement retrieves the current date from the Real Time Clock.

Syntax:

GETDATE *month*, *day*, *year*, *wday*

Arguments:

month an integer variable. The month is stored in this variable. The months are represented as 1-Jan, 2-Feb, ..., 12-Dec.

day an integer variable. The day of the month is stored in this variable. The days are represented as 1..31.

year an integer variable. The year is stored in this variable. The years are represented as 0..99.

wday an integer variable. The day of the week is stored in this variable. The days are represented as 1-Sunday, 2-Monday, ..., 7-Saturday. On the UCP, this value is always returned as 0.

Description:

GETDATE reads the current date from the Real Time Clock. Note that the Real Time Clock is an option on the Boss Bear. GETDATE takes about 200 microseconds to execute.

UCP: The UCP uses a Touch Memory device for the real time clock. The GETDATE statement takes about 150 milliseconds to execute on the UCP, which is much longer than the Boss Bear.

Example:

```
100  INTEGER MONTH, DAY, YEAR, WDAY
110  STRING WD$(22)
120  WD$="SunMonTueWedThuFriSat"
130  GETDATE MONTH, DAY, YEAR, WDAY
140  PRINT "The date is "; MID$(WD$, WDAY*3-2, 3); " ";
150  PRINT MONTH; "/"; DAY; "/"; YEAR
```

This produces the following output when run:

```
The date is Wed 10/24/90
```

Related topics:

GETIME, SETDATE, SETIME

GETIME Statement

Summary:

The GETIME statement retrieves the current time from the Real Time Clock.

Syntax:

GETIME *hours*, *minutes*, *seconds*

Arguments:

hours an integer variable. The hours are stored in this variable. The hours are represented as 0..23, with 0 being midnight.

minutes an integer variable. The minutes are stored in this variable. The minutes are represented as 0..59.

seconds an integer variable. The seconds are stored in this variable. The seconds are represented as 0..59.

Description:

GETIME reads the current time from the Real Time Clock. Note that the Real Time Clock is an option on the Boss Bear. GETIME takes about 200 microseconds to execute.

UCP: The UCP uses a Touch Memory device for the real time clock. The GETIME statement takes about 150 milliseconds to execute on the UCP, which is much longer than the Boss Bear.

Example:

```
100  INTEGER HOUR, MIN, SEC
110  GETIME HOUR, MIN, SEC
120  PRINT "The time is "; HOUR; ":"; MIN; ":"; SEC
```

This produces the following output when run:

```
The time is 17:25:56
```

Related topics:

SETDATE, SETIME, GETDATE

GO Direct Command

Summary:
The GO direct command starts the compiled code executing.

Syntax:
GO (may be abbreviated G)

Arguments:
GO needs no arguments.

Description:
GO begins execution of the most recently COMPILEd or RUN program. If the source code has been modified, a NEW command has been executed, or an error was detected in the last compile, then the `No Compiled Code` error will be displayed. GO is typically used to run a program previously compiled via the RUN or COMPILE commands. If the program is very long, then GO is faster than using RUN repeatedly, since RUN must first recompile the program.

Related topics:
COMPILE, RUN, NEW

GOSUB Statement

Summary:
The GOSUB statement is used to call a subroutine.

Syntax:
GOSUB *linenum*

Arguments:
linenum a line number in the BASIC program.

Description:
It is often useful in a program to be able to execute a section of code from many places in the program. Instead of using duplicate code in each spot that needs it, a subroutine may be created and then called with GOSUB. When a GOSUB is encountered, program execution continues at *linenum*, until a RETURN statement is executed, at which point BASIC will transfer execution to the statement following the GOSUB. Subroutines have three main advantages: they make the program smaller by eliminating redundant code, they allow the logic to be debugged once and used many places, and they can make the program easier to understand by hiding the details of the lower levels of the program.

Example:
```
100  REAL SLOPE(1), OFFSET(1), ADJST(1)
110  INTEGER CHANL
120  SLOPE(0)=0.432: OFFSET(0)=11.5       ' Set up coefficients for chan 0
130  SLOPE(1)=1.28: OFFSET(1)=-5.29       ' Set up for chan 1
140  ADJST(0)=ADC(2)                      ' Read value for chan 0
150  ADJST(1)=ADC(5)                      ' Read value for chan 1
160  FOR CHANL=0 TO 1
170    GOSUB 1000                         ' Perform adjustment
180    PRINT "Adjusted value = "; ADJST(CHANL)
190  NEXT CHANL
200  STOP
1000 ' Subroutine to perform a Y=MX+B adjustment.
1010 ADJST(CHANL)=SLOPE(CHANL)*ADJST(CHANL)+OFFSET(CHANL)
1020 RETURN
```

This produces the following output when run:

```
Adjusted value = 1241.83600
Adjusted value = 465.75000
```

Related topics:
GOTO, RETURN

GOTO Statement

Summary:
The GOTO statement transfers execution to a specific program line.

Syntax:
GOTO *linenum*

Arguments:
linenum a line number in the BASIC program.

Description:
GOTO *linenum* causes execution of the BASIC program to continue at line *linenum*.

Example:
```
100  PRINT "Line 100"
110  GOTO 200
120  PRINT "Line 120"
130  STOP
200  PRINT "Line 200"
210  GOTO 120
```

This produces the following output when run:

```
Line 100
Line 200
Line 120
```

Related topics:
GOSUB

GOTOXY Statement

Summary:

The GOTOXY statement positions the cursor on the current FILE output device.

Syntax:

GOTOXY *xpos*, *ypos*

Arguments:

xpos a numeric expression. The horizontal position to put the cursor at, starting at 0.

ypos a numeric expression. The vertical position to put the cursor at, starting at 0.

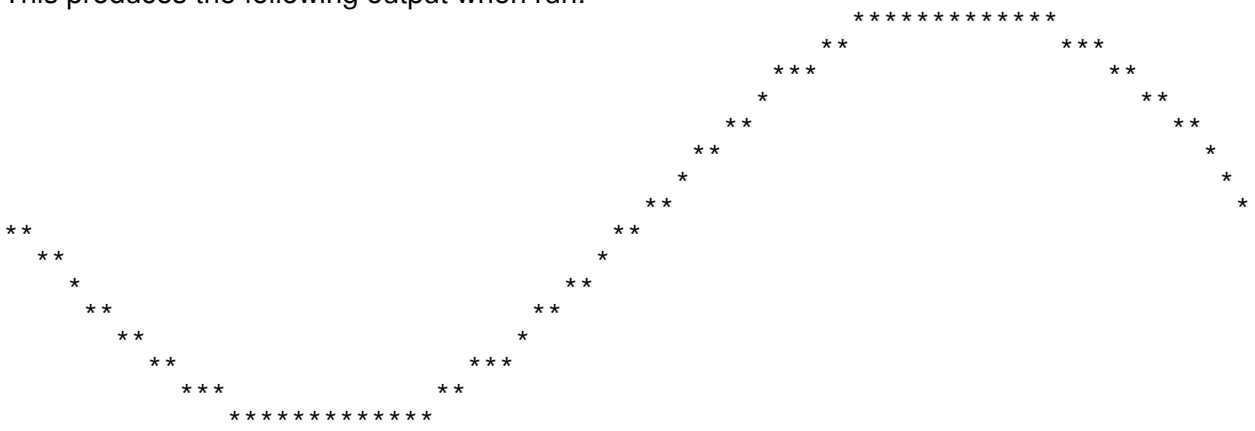
Description:

GOTOXY is used to position the cursor on the current FILE output device, using a Cartesian coordinate system with (0,0) at the upper left corner. Each task maintains its own cursor position, so that two tasks may print to a device at different locations at the same time. GOTOXY works with the onboard display (FILE 6), as well as with COM1 (FILE 0) and COM2 (FILE 5); in order to work with FILE 0 and FILE 5, the terminal must be able to emulate the ADM3A command set.

Example:

```
100  'Example to display a sine wave on the terminal
110  REAL X,Y: INTEGER J
120  CLS
130  FOR J=0 TO 79               ' Use entire display
140    X=J * 360.0 / 79.0              ' Scale to 360 degrees
150    Y=SIN(X) * 8.0 + 9.0                  ' Scale to +/- 8, with 0 in center
160    GOTOXY J,Y: PRINT "*";          ' Draw the point
170  NEXT J
```

This produces the following output when run:



Related topics:

LOCATE

HELP Direct Command

Summary:

The HELP direct command displays online help screens.

Syntax:

HELP

Arguments:

HELP needs no arguments.

Description:

HELP causes a set of online help screens to be displayed. The space bar must be pressed at the end of each screen to cause the next screen to be displayed; any other key will abort the help command and return to the compiler prompt.

IF..THEN Statement

Summary:

The IF..THEN statement controls program flow based on a relational expression.

Syntax:

IF *rel_expr* THEN *statement* [: *statement*]...

Arguments:

rel_expr a numeric or string expression. This is evaluated as a TRUE or FALSE value, with nonzero values being TRUE and zero being FALSE.

statement BASIC statement to be executed if *rel_expr* is TRUE.

Description:

In general, the power of the computer is based upon its ability to make decisions based on its input data. The IF..THEN statement is used in Bear BASIC to control the flow of program execution based on the result of a calculation. *rel_expr* is evaluated; if it is TRUE (nonzero), then *statement* is executed. If *rel_expr* is FALSE (zero), then program execution continues at the next line. Usually, *rel_expr* will be a comparison between variables or expressions; for example: `J=5`, `K>=N+3`, or `A$<>B$`. However, since it is being evaluated as a TRUE or FALSE value, *rel_expr* may just be a variable by itself; for example, the statement `IF J THEN...` will be executed if J is nonzero. For integer and real expressions, the relational operators are: AND, OR, >=, <=, =, <>, >, and <. For string expressions, the relational operators are: =, <>, >, and <.

Note that if *rel_expr* is TRUE, then the rest of the line is executed. This means that multiple statements can be placed after THEN; the statements will only be executed if the expression is TRUE.

Often, *statement* will be a GOTO statement; for example: `IF X>3.5 THEN GOTO 260`. The compiler accepts a shortened form of this, in which the word GOTO is left out; ie. `IF X>3.5 THEN 260`. The compiler will insert the GOTO into the statement, so when the line is listed it will read `IF X > 3.5 THEN GOTO 260`

Examples:

```
100  INTEGER J,K,N
110  J=3: K=5: N=0
120  PRINT "J=3: "; J=3; "  J>3: "; J>3
130  IF J=3 THEN PRINT "J = 3";: PRINT "...";
140  PRINT
150  IF J>3 THEN PRINT "J > 3";: PRINT "...";
160  PRINT
170  IF J<5 AND K>2 THEN PRINT "Passed line 170"
180  IF K THEN PRINT "K is TRUE"
190  IF N THEN PRINT "N is TRUE"
```

This produces the following output when run:

```
J=3: 257  J>3: 0
J = 3...

Passed line 170
K is TRUE
```

```
100  STRING A$,B$
110  A$="ABC": B$="ABD"
120  IF A$<>B$ THEN PRINT "Strings not equal"
130  IF A$<>"" THEN PRINT "1..String not empty"
140  A$=""
150  IF A$<>"" THEN PRINT "2..String not empty"
```

This produces the following output when run:

```
Strings not equal
1..String not empty
```

Related topics:

Chapter 3

INP Function

Summary:

The INP function reads the current value from a hardware input port.

Syntax:

val = INP (*port*)

Arguments:

port an integer expression between 0 and 255. The hardware port number to read from.

Description:

The Boss Bear processor interfaces with the real world through Input/Output (I/O) devices. The Boss Bear architecture supports both memory mapped devices, which are accessed using PEEK and POKE, and I/O mapped devices, which are accessed using INP and OUT. It requires a thorough understanding of the Boss Bear hardware in order to use INP and OUT; usually, the only time that these would be used is when copying example code supplied by Divelbiss in an application note.

INP reads a single byte value (ie. an integer between 0 and 255) from a hardware input port. If there is no hardware device located at *port*, then an indeterminate value will be returned.

Example:

```
100  INTEGER J
110  J=INP($9F)
```

Related topics:

OUT, Chapter 7

INPUT Statement

Summary:

The INPUT statement waits for a data value to be entered on the current FILE device.

Syntax:

INPUT *variable* [,*variable*]...

Arguments:

variable a BASIC variable name. The value entered is stored in this variable.

Description:

The INPUT statement is used to enter data while the program is running. It waits for a data value, followed by a carriage return, to be entered on the current FILE, then it stores that value into a BASIC variable. The BACKSPACE key may be used to modify the input data before pressing ENTER. In a multitasking program, other tasks will continue executing while this task is waiting for input; multiple tasks can even execute INPUT at the same time on different FILEs. INPUT is particularly well suited to reading data that is being sent over one of the serial ports; if data is to be entered by the user, then FINPUT will probably work better.

If multiple *variable*s are specified, then multiple data values can be entered separated by commas. For example, `INPUT J,K,X` will accept `4,12,3.76` as a valid input. Note, however, that it does not verify that the correct number of values was entered; with the previous example, if `10,8` were entered, then X would retain its original value, since no new value was entered. Likewise, if `3,4,10.32,8` were entered, then the 8 would be thrown away, since there is no variable for it to be assigned to; J would be set to 3, K to 4, and X to 10.32, and no error would be generated.

If *variable* is a string, then commas and control characters cannot be read by INPUT. Commas are used as delimiters between input data values; if necessary, the INPUT$ statement allows commas and most control characters to be entered.

If *variable* is an integer or real and a string is entered, then the error message `*** Bad Input: Please Re-enter ***` will be displayed and it will wait for another value to be entered. Note that this could make a mess out of the screen display, if the input is being typed by a user; for this reason, it is probably better to get user input using FINPUT. If multiple numeric variables are to be input, then this error will also be displayed if any spaces are entered.

INPUT should not be used in an interrupt task, because it re-enables interrupts and allows multitasking to continue. Depending upon what the other tasks are doing at the instant that the interrupt task executes, INPUT could cause the system to lock up.

Examples:

```
100  STRING A$
110  PRINT "What is your name? ";
120  INPUT A$
130  PRINT "Hello, "; A$
```

This example shows how text can be INPUT into a string variable. Run this and try using BACKSPACE to modify the string. Also try entering commas in the string.

```
100  INTEGER J,K
110  REAL X
120  PRINT "Enter J, K, X > ";
130  INPUT J,K,X
140  PRINT J,K,X
```

This example shows how multiple items can be entered with one INPUT statement. Run this and try entering more or less than three numbers.

```
100  INTEGER J,K
110  RUN 1
120  INPUT J
130  PRINT "The value entered is "; J
140  STOP
150  TASK 1
160  FILE 6
170  INPUT K
180  PRINT "K = "; K
190  EXIT
```

This example shows how INPUT can be used concurrently in multiple tasks.

Related topics:

INPUT$, FINPUT, GET, KEY

INPUT$ Statement

Summary:

The INPUT$ statement is identical to INPUT, except that it allows commas and some control characters to be entered in strings.

Syntax:

INPUT$ *variable* [,*variable*]...

Arguments:

variable a BASIC variable name. The value entered is stored in this variable.

Description:

The INPUT$ statement is identical to INPUT, except in its handling of strings. Whereas INPUT won't accept commas and control characters in strings, INPUT$ accepts commas and most control characters. The only delimiter used by INPUT$ is the carriage return, which signals the end of data entry. For example, `INPUT$ COLOR$` would accept `red, green, blue` and leave COLOR$ holding the string "red, green, blue".

Note that there should only be one string *variable* field, and that no integer or real *variable*s can follow the string, since there is no way for it to detect the end of the string except for the carriage return. For example, with the code `INPUT$ J,A$,K` there is no way to enter a value into K, because, if the user types `12,widget7,9` then J will be 12, A$ will be "widget7,9", and K will be unchanged.

INPUT$ should not be used in an interrupt task, because it re-enables interrupts and allows multitasking to continue. Depending upon what the other tasks are doing at the instant that the interrupt task executes, INPUT$ could cause the system to lock up.

Examples:

```
100  INTEGER J,K
110  STRING A$(80)
120  INPUT$ J,K,A$
130  PRINT J,K,A$
```

Related topics:

INPUT, FINPUT, GET, KEY

INTEGER Statement

Summary:
The INTEGER statement is used to declare integer variables.

Syntax:
INTEGER *variable* [,*variable*]...

Arguments:
variable a text string. The name to use for the variable. Variable names in Bear BASIC consist of an alphabetic character followed by up to 6 alphanumeric characters. To declare an array, this will be followed by one or two numbers enclosed in parenthesis. The following are valid integer variable names: J, J(20), PRESURE, CHAN5, TIME4(10), J(10,7).

Description:
Integer variables are used to hold numeric data that ranges between -32768 and 32767. Integers are stored in 16 bit, two's complement form, and therefore take up 2 bytes each. All variables in a Bear BASIC program must be declared as INTEGER, REAL, or STRING; all variable declarations must occur before any executable statements in the BASIC program.

Integer arrays may be declared with the INTEGER statement, as well. Bear BASIC allows one and two dimensional arrays. The variable name is followed by parenthesis enclosing one or two array dimensions, such as J(5) or J(7,5). Note that the array dimension is not the number of array elements, but the number of the last array element; arrays always start with element 0. The array J(5) actually contains 6 variables, J(0) through J(5).

Example:
```
100  INTEGER J,K
110  INTEGER CHAN(9)                ' Array of 10 integers: 20 bytes
120  INTEGER TDAT(4,19)             ' 5 by 20 array: 200 bytes
130  FOR J=0 TO 9
140    CHAN(J)=J                    ' Shows how arrays are accessed
150    TDAT(0,J)=J*4
160  NEXT J
```

Related topics:
REAL, STRING

INTERRUPT Statement

Summary:

The INTERRUPT statement attaches a task to a hardware interrupt source, so that the task becomes the handler for that interrupt.

Syntax:

INTERRUPT *device*, *chan*, *task*

Arguments:

device an integer expression. The type of device to work with:
1 = High speed counter
2 = Future expansion

chan an integer expression. The channel number of the device, from 1 up to the number of channels available.

task an integer expression between 1 and 31. The number of the task to be attached to the device.

Description:

The INTERRUPT statement provides a simple way to write interrupt service routines in Bear BASIC. It causes a task to be executed when a specific hardware interrupt occurs. For example, `INTERRUPT 1,5,3` will cause task 3 to be executed when high speed counter number 5 causes an interrupt.

Example:

```
100  ' Program to demonstrate INTERRUPT using the high speed counter
110  INTEGER J, RELOAD, COUNT
120  CNTRMODE 1,4                    ' A count, B direction
130  WRCNTR 1,0,0                    ' Set count to 0
140  RELOAD=5: COUNT=0
150  WRCNTR 1,1,RELOAD               ' Set counter interrupt value
160  INTERRUPT 1,1,1                 ' Set counter interrupt to task 1
170  J=0
180  FILE 6
200  ' Main program loop.
210  LOCATE 1,1
220  FPRINT "U5X5U5Z", J, COUNT
230  J=J+1                           ' Increment junk variable
240  GOTO 210
300  ' Counter interrupt handler task.
310  TASK 1
320  RDCNTR 1,0,COUNT                ' Get new count
330  RELOAD=RELOAD+5                 ' Set up new reload
340  WRCNTR 1,1,RELOAD               ' Set counter interrupt value
350  EXIT
```

This example sets up task 1 as the interrupt handler for counter 1. In lines 120 and 130 it initializes counter 1, setting its mode to A-count, B-direction and writing a 0 to the counter. In lines 140 and 150 it sets the counter reload variable to 5 and writes this reload value into the counter's compare register. Line 160 uses INTERRUPT to set task 1 as the interrupt handler for the counter. Lines 210 to 240 form the program's main loop, which just displays the latest counter value (COUNT) from the last interrupt; it also increments and displays J,

just to cause some action on the display. Line 300 to 350 form task 1, the interrupt handler; it reads the current counter value and updates the reload value.

In task 1, the first thing that it does is read the current counter value. At low pulse rates, this will be the same as RELOAD, since it is reading the same value that caused the interrupt. As the pulse rate increases, however, the counter will increment before the task 1 gets to read the counter. At a very high pulse rate, a problem will occur when the counter has already gone beyond the new RELOAD value before RELOAD is written to the counter (ie. COUNT=783 and RELOAD=780); the counter will need to wrap completely around before the interrupt will occur again.

Related topics:

Chapter 7

INTOFF Statement

Summary:
The INTOFF statement disables all processor interrupts.

Syntax:
INTOFF

Arguments:
INTOFF needs no arguments.

Description:
It is sometimes necessary to temporarily stop the processor from handling hardware interrupts, for two reasons: to stop an interrupt handler from modifying a variable that another routine needs to access, and because a section of code needs to execute extremely quickly and interrupt processing would slow it down. INTOFF stops the processor from handling interrupts; INTON enables the interrupt processing again. Interrupts should only be turned off for very short periods; if they are off for too long, then characters coming in on the serial ports could be lost, the timing of tasks with WAIT statements could slow down, or hardware events could be handled erratically.

The Boss Bear uses a hardware timer interrupt to run the multitasking context switcher, so executing INTOFF stops the multitasking operation. This can be used to keep one task from corrupting a variable used in another task, for example. Some instructions enable interrupt processing as part of their execution: INTON, WAIT, EXIT, INPUT, INPUT$, GET, FINPUT, PRINT, FPRINT, NETWORK 1, NETWORK 2, and any string operations. These instructions should not be used after an INTOFF, since they will defeat the purpose by re-enabling interrupts.

If interrupts are left off for too long (more than 0.5 second) then the watchdog may reset the system. Some BASIC statements reset the watchdog, and so this will not happen if those statements are executed.

Example:
```
100  INTEGER D,J,K,N
110  RUN 1,1
120  FOR J=1 TO 1000
130    INTOFF
140    K=2
150    N=J*K/2
160    D=J+K-N
170    INTON
180    FPRINT "U5Z",D
190  NEXT J
200  PRINT: STOP
210  ' Task to demonstrate variable corruption
220  TASK 1
230  K=9999
240  EXIT
```

This example shows that a task can corrupt a variable that another task is using. In this case, task 1 modifies the value of K, which the main routine is using in lines 140 to 160. Without the INTOFF in line 130, the context switcher could start task 1 running at any time, including while the main routine is in line 140, 150 or 160, thus changing the value of K from 2 to 9999. This would drastically affect the outcome of the calculation. To demonstrate this, run the program as it is shown; it should print "2" 1000 times. Then remove lines 130 and 170 and run the program again; this time it will print mostly "2", with other numbers interspersed periodically. The other numbers are caused when task 1 executes while task 0 (the main routine) is in line 140, 150, or 160.

Related topics:

INTON

INTON Statement

Summary:
The INTON statement enables processor interrupts.

Syntax:
INTON

Arguments:
INTON needs no arguments.

Description:
INTON is used to re-enable interrupts after an INTOFF statement has disabled interrupt processing. See INTOFF for a detailed description.

Example:
```
100  INTEGER J
110  RUN 1,1
120  INTOFF: DOUT 1,1: DOUT 2,1: INTON
130  WAIT 10
140  INTOFF: DOUT 1,0: DOUT 2,0: INTON
150  WAIT 5: GOTO 120
200  TASK 1
210  PRINT "*";
220  EXIT
```

This example uses INTOFF and INTON to ensure that the two DOUT statements take place at almost the same time. If the interrupts weren't disabled, then task 1 could break in between the two DOUT statements, causing them to occur a few milliseconds apart.

Related topics:
INTOFF

JVECTOR Statement

Summary:

The JVECTOR statement stores a jump instruction to an interrupt service task at the specified address.

Syntax:

JVECTOR *logaddr*, *task*

Arguments:

logaddr	an integer expression. The logical address to store the jump instruction at.
task	an integer expression from 1 through 31. The task number to jump to.

Description:

JVECTOR stores code at *logaddr* to jump to *task*. When the program execution reaches *logaddr*, it will disable interrupt processing and transfer execution to *task*. With the current Boss Bear hardware architecture, JVECTOR has two possible uses: to call a task when the Boss Bear loses power, and to call a task when a fatal program error occurs.

Examples:

```
100  INTEGER X
110  JVECTOR $66,1                  ' Set up NMI vector to task 1
120  GOTO 120                       ' Wait for power to be turned off
200  TASK 1                         ' This is the NMI task
220  PRINT "*";                     ' Print until processor halts
230  GOTO 220
```

The power management circuitry activates the Non-Maskable Interrupt (NMI) line when the 12V power source drops below approximately 9V. Then, when the processor power drops below about 4.6V, it will be halted; this leaves a little bit of time between when the NMI occurs and when the processor is halted. The example shows how to set up a task to run when power is lost. This task could be used to disable output control lines, write a data value to EEPROM, etc. The example sets up the NMI task and then sits in a loop; when the power is switched off, the NMI task will output '*' characters until the processor finally halts. This demonstrates how much time is available between power loss and system lockup; each '*' takes about 1 msec to send at 9600 baud. The vector for the NMI is at address $66.

```
100  REAL X
110  JVECTOR $13,1                  ' Set up vector to task 1 on error
120  X=3.5/0.0                      ' Cause a "Divide by 0" error
130  PRINT "Done": STOP
130  ' Fatal program error handler
140  TASK 1
150  PRINT "Error "; ERR            ' Print error message
160  CALL $100                      ' Restart BASIC program
```

When a program error occurs, such as `Return Without Gosub` or `Subscript Out of Range`, Bear BASIC normally prints an error message on the console terminal and returns to the

compiler prompt. By using JVECTOR, it is possible to trap the error and handle it in the BASIC program. The vector for the error handler is at address $13. Normally, PRINT should not be executed inside of an interrupt service task (see line 150), but since no other PRINT could be active in this program, it should work. In line 160, it restarts the BASIC program by jumping to the starting address for the program; all Bear BASIC programs start at $100.

Related topics:

VECTOR, ON ERROR, ERR, Chapter 11

KEY Function

Summary:
The KEY function reads one byte from the current FILE; it doesn't wait if no byte is available.

Syntax:
x = KEY

Arguments:
KEY needs no arguments.

Description:
KEY returns a byte from the current FILE if one is available; the byte is returned as an integer value. 0 is returned if no byte is available; if the byte's value is 0, then it is returned as 256 ($100). KEY returns all bytes entered, no control codes are filtered out.

Since KEY goes through the normal FILE routines, it provides an autorepeat function when accessing the onboard keypad (FILE 6). Sometimes, it is desirable to access the keypad directly, as if it were an input module. The DIN function can be used to get the current keypad state, without performing the autorepeat. See the DIN description for more information.

KEY should not be used in an interrupt task, because it re-enables interrupts and allows multitasking to continue. Depending upon what the other tasks are doing at the instant that the interrupt task executes, KEY could cause the system to lock up.

Example:
```
100  INTEGER N,K: N=0
110  K=KEY                          ' Get a key, if one is available
120  FILE 6: LOCATE 1,1: PRINT N    ' Display counter on onboard display
130  FILE 0: N=N+1
140  IF K=0 THEN 110                ' If no key then continue waiting
150  IF K=256 THEN K=0              ' Check for 0 byte value
160  PRINT "Key = "; K: GOTO 110
```

This example gets characters from the console and displays the value of the characters; it also displays a counter on the onboard display, to show that KEY is not waiting. Line 110 gets the byte from the console. Line 120 prints the counter on the onboard display; note that it changes to FILE 6, prints the counter, then changes back to FILE 0. Line 140 loops back if no byte was retrieved. Line 150 handles the 0 value, which would have been returned as 256; in this example, it is unlikely that a 0 would have been entered over the console port.

Related topics:
GET, INPUT, INPUT$, FINPUT, FILE, DIN, Chapter 5

LEN Function

Summary:

The LEN function returns the length of a string.

Syntax:

x = LEN (*st$*)

Arguments:

st$ a string expression.

Description:

LEN returns the number of characters currently contained in *st$* as an integer value. It does not return the maximum size of *st$*; for example, if a string was declared as STRING NAME$(40), it will not return 40 unless there is a 40 character string stored in NAME$.

Example:

```
100  STRING A$(80)
110  PRINT "Enter a string > ";
120  INPUT A$
130  PRINT "String length = "; LEN(A$)
```

Related topics:

LFDELAY Direct Command

Summary:

The LFDELAY direct command causes a slight delay to be performed with each carriage return, line feed that is sent to the console.

Syntax:

LFDELAY

Arguments:

LFDELAY needs no arguments.

Description:

Some video terminals cannot scroll the screen fast enough to keep up at 9600 baud; they will lose the first few characters at the beginning of each line. The LFDELAY command causes the Boss Bear to pause at the beginning of each line to allow the terminal to catch up. Once the LFDELAY command is issued, it remains in effect until the Boss Bear is reset by executing the BYE command or turning the power off and back on.

LIST Direct Command

Summary:

The LIST direct command displays the current BASIC program.

Syntax:

LIST [*start*] [, *end*]

Arguments:

start	a valid BASIC line number. The first line number to display.
end	a valid BASIC line number. The last line number to display.

Description:

LIST displays the program currently in memory on the system's console terminal. If LIST is typed with no arguments, or just L is typed, then the entire program will be listed. If LIST is typed and only *start* is specified, then only that line will be listed (if it exists). If both *start* and *end* are specified, then the program from *start* through *end* will be listed.

Examples:

`LIST`	Lists the entire program.
`L`	Lists the entire program.
`LIST 190`	Lists line 190, if it exists.
`LIST 190,240`	Lists lines 190 through 240.

LOAD Direct Command

Summary:

The LOAD direct command loads a BASIC program from the user's EPROM.

Syntax:

LOAD [*filenum*]

Arguments:

filenum an integer number from 1 through the number of files stored on the EPROM. The number of the file to load.

Description:

If *filenum* is specified, then LOAD loads source file number *filenum* from the EPROM, otherwise, it loads the last source file from the EPROM. LOAD is identical to EPROM LOAD.

Example:

`LOAD`	Loads the last source file.
`LOAD 3`	Loads the third source file.

Related topics:

SAVE, EPROM LOAD, EPROM SAVE

LOCATE Statement

Summary:

The LOCATE statement positions the cursor on the current FILE output device.

Syntax:

LOCATE *row*, *column*

Arguments:

row	a numeric expression. The vertical position to put the cursor at, starting at 1.
column	a numeric expression. The horizontal position to put the cursor at, starting at 1.

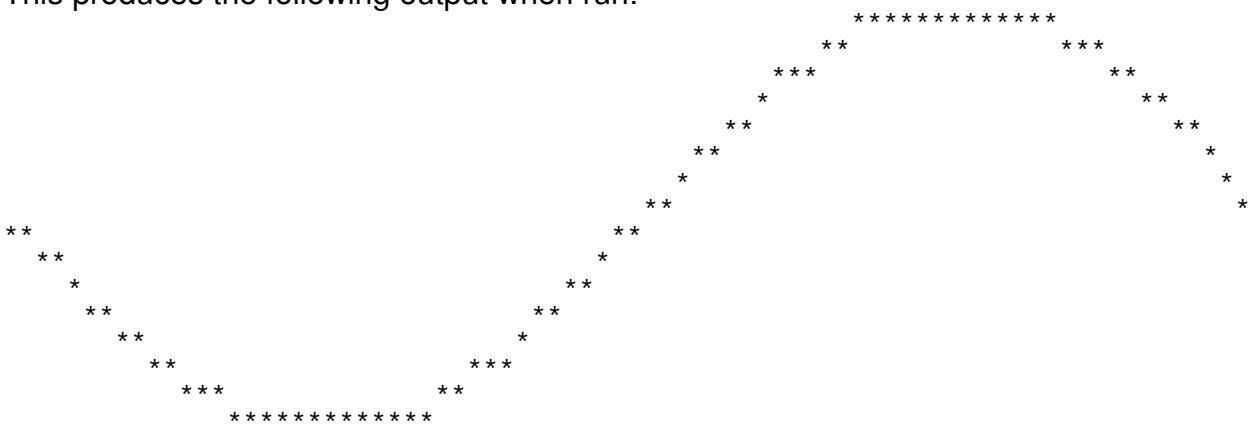
Description:

LOCATE is used to position the cursor on the current FILE output device, using a row/column coordinate system with (1,1) at the upper left corner. Each task maintains its own cursor position, so that two tasks may print to a device at different locations at the same time. LOCATE works with the onboard display (FILE 6), as well as with COM1 (FILE 0) and COM2 (FILE 5); in order to work with FILE 0 and FILE 5, the terminal must be able to emulate the ADM3A command set.

Example:

```
100  'Example to display a sine wave on the terminal
110  REAL X,Y: INTEGER J
120  CLS
130  FOR J=0 TO 79               ' Use entire display
140    X=J * 360.0 / 79.0              ' Scale to 360 degrees
150    Y=SIN(X) * 8.0 + 9.0                  ' Scale to +/- 8, with 0 in center
160    LOCATE Y+1,J+1: PRINT "*";' Draw the point
170  NEXT J
```

This produces the following output when run:



Related topics:

GOTOXY

LOG Function

Summary:
The LOG function calculates the natural logarithm (base e) function.

Syntax:
x = LOG (*expr*)

Arguments:
expr a numeric expression.

Description:
The LOG function returns the natural logarithm of *expr*, which must be a numeric expression. The result is returned as a REAL value.

By using the properties of logarithms, a number X can be raised to a power Y (X^Y) using `EXP(LOG(X)*Y)`.

To calculate the common logarithm (LOG_{10}) of X, use LOG10.

Example:
```
100  REAL X,Y
110  PRINT LOG(72.35)
120  X=0.82
130  Y=LOG(X)
140  PRINT "Logarithm of ";X;" is ";Y
150  PRINT "4 cubed = "; EXP(LOG(4)*3)
```

This produces the following output when run:

```
4.28151
Logarithm of .82000 is -.19845
4 cubed = 64.00003
```

Related topics:
LOG10, EXP

LOG10 Function

Summary:
The LOG10 function calculates the common logarithm (base 10) function.

Syntax:
x = LOG10 (*expr*)

Arguments:
expr a numeric expression.

Description:
The LOG10 function returns the common logarithm of *expr*, which must be a numeric expression. The result is returned as a REAL value.

To calculate the natural logarithm of X, use LOG.

Example:
```
100  REAL X,Y
110  PRINT LOG10(72.35)
120  X=0.82
130  Y=LOG10(X)
140  PRINT "Common logarithm of ";X;" is ";Y
```

This produces the following output when run:

```
1.85944
Common logarithm of .82000 is -.08619
```

Related topics:
LOG, EXP

MID$ Function

Summary:

The MID$ function returns a substring of a specified string.

Syntax:

*st$* = MID$ (*strexpr$*, *start*, *num*)

Arguments:

strexpr$	a string expression.
start	a numeric expression. The start of the substring.
num	a numeric expression. The number of characters in the substring.

Description:

MID$ returns a string that is a substring of *strexpr$*. The substring will begin at *start* in *strexpr$* and continue for *num* characters. MID$ must not go beyond the end of *strexpr$*; if *start* + *num* is greater then LEN(*strexpr$*), then a `String Length Exceeded` error will result.

Example:

```
100  STRING A$(60)
110  A$="The quick brown fox jumped over the lazy dog"
120  PRINT "<";MID$(A$,1,3);">"
130  PRINT "<";MID$(A$,20,10);">"
140  PRINT "<";MID$(A$,38,LEN(A$)-37);">"
150  PRINT "<";CONCAT$(MID$(A$,5,6),MID$(A$,17,3));">"
```

This produces the following output when run:

```
<The>
< jumped ov>
<azy dog>
<quick fox>
```

In line 140, the LEN function is used to ensure that MID$ doesn't try to go beyond the end of A$, which would cause an error.

Related topics:

LEN

MKI$ Function

Summary:
The MKI$ function converts an integer to a binary string.

Syntax:
*st$* = MKI$ (*intexpr*)

Arguments:
intexpr an integer expression.

Description:
A binary string is a string that may contain more than just ASCII text data; it may contain bytes that are not valid ASCII characters. Because of this, they are not usually human-readable. A binary string is really just an array of numeric bytes. The main use for binary strings is to provide a more efficient way to transfer blocks of numeric data over the serial ports; numbers stored in binary strings take up fewer bytes than numbers stored as ASCII characters. The functions MKI$, CVI, MKS$, and CVS are provided to work with binary strings.

The MKI$ function returns *intexpr* as a two byte string. For example, `MKI$($1234)` returns a string whose first byte is $34 and whose second byte is $12; note that $1234 takes up 4 characters when stored in ASCII, but only 2 when stored in binary form.

Example:
```
100  INTEGER J
110  STRING A$: A$=""
120  FOR J=$3030 TO $3036
130    A$=CONCAT$(A$,MKI$(J))
140  NEXT J
150  PRINT A$
160  FOR J=1 to LEN(A$)
170    FPRINT "H2X2Z",ASC(MID$(A$,J,1))
180  NEXT J
190  PRINT
200  J=CVI(A$): FPRINT "H4",J
```
This produces the following output when run:

```
00102030405060
30  30  31  30  32  30  33  30  34  30  35  30  36  30
3030
```

The first line printed shows how the 7 integers $3030 through $3036 were stored in A$; these numbers were chosen so that A$ would still be a printable string. The second line shows how the individual bytes are stored in the string. The third line shows that CVI can be used to convert the first two bytes of A$ back to an integer.

Related topics:
CVI, MKS$, CVS

MKS$ Function

Summary:
The MKS$ function converts a real to a binary string.

Syntax:
*st$* = MKS$ (*realexpr*)

Arguments:
realexpr a real expression.

Description:
The MKS$ function returns *realexpr* as a four byte string. For example, `MKS$(123.456)` returns a string whose bytes are $42, $F6, $E9, $78; note that 123.456 takes up 7 characters when stored in ASCII, but only 4 when stored in binary form. See MKI$ for more information on binary strings.

Example:
```
100  INTEGER J: REAL X
110  STRING A$: A$=""
120  FOR X=1.0 TO 3.0
130    A$=CONCAT$(A$,MKS$(X))
140  NEXT X
150  FOR J=1 to LEN(A$)
160    FPRINT "H2X2Z",ASC(MID$(A$,J,1))
170  NEXT J
180  PRINT
190  X=CVS(A$): PRINT X
```

This produces the following output when run:

```
3F  80  00  00  40  00  00  00  40  40  00  00
1.00000
```

The first line printed shows how the 3 reals 1.0, 2.0, and 3.0 were stored in A$. The second line shows that CVS can be used to convert the first four bytes of A$ back to a real.

Related topics:
CVS, MKI$, CVI

NETMSG Function

Summary:

The NETMSG function sends and receives messages over the network. It returns an error code.

Syntax:

ercode = NETMSG (*message$*,*rdwr*,*unit*)

Arguments:

message$ if *rdwr* is 0, then *message$* is a string expression; this string will be sent to the specified unit. If *rdwr* is 1, then *message$* is a string variable; if a message is available in the receive buffer, then it will be returned in *message$*.

rdwr an integer expression that evaluates to 0 or 1. 0 indicates that the message is to be sent to another unit, while 1 indicates that a message should be read from the network buffers, if one is waiting.

unit if *rdwr* is 0, then *unit* is the network address of the unit to send the message to, and should be an integer expression that evaluates between 0 and 255. If *rdwr* is 1, then *unit* is an integer variable that will be set to the network address of the unit that sent the message.

Description:

The NETMSG function performs two different, but related, functions: it sends messages over the network, and retrieves messages that have arrived over the network. In both cases, it returns an integer error code that indicates the success or failure of the operation.

To send a message to another unit, the message is assembled into a string, then the string is sent with NETMSG(*message$*,*0*,*unit*), which will wait until a response is received or until it times out (in approximately 5 seconds). It returns a 0 if the message was successfully transferred, or a 1 if a timeout error occurred.

Any incoming messages are received and buffered by the low level network handler. NETMSG(*message$*,*1*,*unit*) will return a 0 if no message is waiting in the buffer. It will return a 1 if there is a message; the message will be returned in *message$*, and the number of the unit that sent the message will be returned in *unit*.

Examples:

```
100  INTEGER J,K
110  STRING NM$(127)
200  ' Initialization
210  NETWORK 0,1,1,1,1,J
220  IF J<>0 THEN PRINT "Network initialization failed": STOP
300  ' Send a message to unit 2
310  NM$=CHR$(0)                    ' Message type = 0
320  NM$=CONCAT$(NM$,MKS$(20.0))    ' Send the value 20.0
330  J=NETMSG(NM$,0,2)              ' Send the message to unit 2
340  IF J<>0 THEN PRINT "Network send error": STOP
400  ' Now wait for a response
```

```
410  J=NETMSG(NM$,1,K)
420  IF J=0 THEN GOTO 410           ' Loop if no response yet
430  IF K<>2 THEN GOTO 410          ' Loop if not from unit #2
440  PRINT "Response = ";CVS(MID$(NM$,2,4))
```

The program above is run on one Boss Bear on the network. It initializes the Boss Bear to be unit number 1, sends a message that consists of the number 20.0, and then waits for a response to arrive. The following program is run on another Boss Bear on the network to generate the response to the program above.

```
100  INTEGER J,K
110  STRING IN$(127)
120  REAL X
200  ' Initialization
210  NETWORK 0,2,1,1,1,J
220  IF J<>0 THEN PRINT "Network initialization failed": STOP
300  ' Wait for a message from unit 1
310  J=NETMSG(IM$,1,K)
320  IF J=0 THEN GOTO 310           ' Loop if no message yet
330  IF K<>1 THEN GOTO 310          ' Loop if not from unit #1
400  ' Generate the response message
410  X=SQR(CVS(MID$(IM$,2,4)))      ' Send back the square root
420  IM$=CHR$(0)                    ' Message type = 0
430  IM$=CONCAT$(IM$,MKS$(X))       ' Put the square root in the string
440  J=NETMSG(IM$,0,1)              ' Send the message to unit 1
450  IF J<>0 THEN PRINT "Network send error": STOP
460  GOTO 300                       ' Do it all again
```

This program initializes the Boss Bear to unit number 2, waits for a message from unit number 1, calculates the square root of the number in the message, and sends a message that consists of the square root.

Related topics:

NETWORK 0, NETWORK 1, NETWORK 2, NETWORK 3, NETWORK 4, Chapter 10

NETSERVER Statement

Summary:
The NETSERVER statement starts the UCP as a peer to peer network server.

Syntax:
NETSERVER *units, autotime, debug, year, month, day, hour, minute*

Arguments:

units	an integer value of 1 to 31. This indicates the number of networked units on the line.
autotime	an integer value of 0 or 1. This turns on or off the autotime feature. 0 for OFF, 1 for ON.
debug	an integer value of 0 or 1. This turns on or off the debug feature. 0 for OFF, 1 for ON.
year	an integer expression. This value specifies the year. This is used with the autotime feature.
month	an integer expression. This value specifies the month. This is used with the autotime feature.
day	an integer expression. This value specifies the day. This is used with the autotime feature.
hour	an integer expression. This value specifies the hour. This is used with the autotime feature.
minute	an integer expression. This value specifies the minute. This is used with the autotime feature.

Description:
The **NETSERVER** statement is used to set up a UCP as a dedicated peer to peer network server. Once this statement is run the UCP will only act as a server. The statement does not return control to basic. It must be noted that this command can only be used on one unit in the network and must not be used when a computer with a network card is on the network.

Example:

```
100  INTEGER YEAR,MONTH,DAY,WDAY,HOUR,MINUTE,SECOND
110  GETDATE MONTH,DAY,YEAR,WDAY
120  GETTIME HOUR,MINUTE,SECOND
130  PRINT "STARTING NETWORK FOR TWO UNITS"
140  'Start the network with autotime enabled
150  NETSERVER 2,1,0,YEAR,MONTH,DAY,HOUR,MINUTE
```

Related topics:
NETWORK 0, NETWORK 1, NETWORK 2, NETWORK 3, NETWORK 4, Chapter 10

NETWORK 0 Statement

Summary:

The NETWORK 0 statement initializes the network handler on the Boss Bear.

Syntax:

NETWORK 0, *unit_id*, *num_int*, *num_real*, *num_string*, *status*

Arguments:

unit_id an integer expression that evaluates between 1 and 254. This is the unit number of this Boss Bear in the network. Each unit in the network must have a unique number.

num_int an integer expression. This is the number of INTEGER registers to allocate space for.

num_real an integer expression. This is the number of REAL registers to allocate space for.

num_string an integer expression. This is the number of STRING registers to allocate space for.

status an integer variable. This will hold the status of the NETWORK operation; a 0 will indicate successful completion, while a nonzero value will indicate that an error occurred.

Description:

This sets the unit ID for this Boss Bear and allocates space for the network registers. Each unit on the network must have a unique unit ID; if two units have the same ID, then neither of them will be able to access the network reliably. The unit ID may range between 1 and 254; for maximum network efficiency, the unit numbers should be allocated sequentially from 1 to N. If there are any unused unit numbers, then the network master will waste time trying to talk to those units periodically.

BASIC accesses the network using a set of network registers; these are just values that are shared between the BASIC program and the network. There are three sets of network registers: one each for INTEGERs, REALs, and STRINGs. The BASIC program controls how many registers are allocated of each type. Each INTEGER register uses 2 bytes, each REAL uses 4 bytes, and each STRING uses 41 bytes. The total space allocated for all three register sets must be less than approximately 20000 bytes. The network registers do not take any variable space away from BASIC; they are stored in a memory segment that BASIC does not normally use (at $2A through $2F).

The network operates through the COM2 serial interface, so FILE 5 (which uses COM2) should not be accessed after the network is initialized. This could slow the network down and possibly corrupt data transfer on the network.

Example:

```
100  INTEGER ST
110  ' Set up this unit's network handler to be unit #3, with
112  ' 200 integer registers, 50 real registers, and 10 string registers.
120  NETWORK 0, 3, 200, 50, 10, ST
130  IF ST<>0 THEN PRINT "Network initialization failed"
```

Related topics:

NETWORK 1, NETWORK 2, NETWORK 3, NETWORK 4, Chapter 10

NETWORK 1 Statement

Summary:

The NETWORK 1 statement sends a block of network registers to another unit on the network.

Syntax:

NETWORK 1, *vartype*, *source_reg*, *number*, *unit_id*, *dest_reg*, *status*

Arguments:

vartype	an integer value of 0, 1, or 2. This indicates the type of network register to send: 0 for INTEGER, 1 for REAL, and 2 for STRING.
source_reg	an integer expression. This is the starting register number of the register block to send.
number	an integer expression. This is the number of registers in the block to send.
unit_id	an integer expression that evaluates between 1 and 254. This is the unit number of the Boss Bear to send to. Each unit in the network must have a unique number.
dest_reg	an integer expression. This is the register number to store the register block at in the destination unit.
status	an integer variable. This will hold the status of the NETWORK operation; a 0 will indicate successful completion, while a nonzero value will indicate that an error occurred.

Description:

The NETWORK 1 statement is used to transfer data to another unit on the network. It sends a block of network registers from this Boss Bear to a register block in another unit. The next time that the network master polls this unit, the registers are transferred; when the destination unit receives the registers, it will acknowledge the reception, and this statement will return. It will wait for at least five seconds for a response before timing out and returning an error; in a multitasking program, it may take longer than five seconds to time out, perhaps as much as 30 seconds or more.

It is often useful to send a register to a different register number in the destination unit. The *source_reg* and *dest_reg* fields determine which registers are sent and where they are stored in the destination unit. For example, `NETWORK 1,0,12,2,3,36,ST` will send INTEGER registers 12 and 13 to unit 3, where they will be stored in INTEGER registers 36 and 37. Of course, a register can be sent to the same register number; for example, `NETWORK 1,1,7,1,2,7,ST` will send REAL register number 7 to unit 2, where it will be stored in register 7.

No range checking is performed. If an attempt is made to read from a register that does not exist, then invalid data will be transferred. If an attempt is made to store into a register that does not exist, then other registers will be overwritten and unpredictable operation may occur.

This statement may not be used concurrently in a multitasking program; in other words, it can't be called from two tasks at the same time. It is highly recommended that all NETWORK 1 and NETWORK 2 statements be located in the same task.

Example:

```
100  INTEGER J, K, ST
110  NETWORK 0,1,20,30,0,ST          ' Initialize the network
120  IF ST THEN PRINT "Init Error"
130  FOR J=0 TO 19
140    NETWORK 3,0,J,J+100,ST        ' Store 100..119 in registers 0..19
150  NEXT J
160  NETWORK 1,0,0,20,2,0,ST         ' Send integer registers to unit 2
170  IF ST THEN PRINT "Timeout"
180  NETWORK 1,0,18,1,3,28,ST        ' Send reg 18 to unit 3, reg 28
190  IF ST THEN PRINT "Timeout"
```

In line 110, the network driver is initialized to unit 1 with 20 INTEGER registers, 30 REAL registers, and 0 STRING registers. In lines 130 to 150, the 20 integer registers (0 to 19) are filled with the values 100 to 119. In line 160, all 20 integer registers are sent to unit 2, where they are stored in the same register locations. In line 180, integer register 18 is sent to unit 3, where it is stored in register 28. Note that in line 160 we are assuming that unit 2 has at least 20 integer registers are available, and in line 180 we are assuming that unit 3 has at least 28 integer registers available.

Related topics:

NETWORK 0, NETWORK 2, NETWORK 3, NETWORK 4, Chapter 10

NETWORK 2 Statement

Summary:

The NETWORK 2 statement reads a block of network registers from another unit on the network.

Syntax:

NETWORK 2, *vartype*, *dest_reg*, *number*, *unit_id*, *source_reg*, *status*

Arguments:

vartype	an integer value of 0, 1, or 2. This indicates the type of network register to read: 0 for INTEGER, 1 for REAL, and 2 for STRING.
dest_reg	an integer expression. This is the first register number to store into in the destination unit.
number	an integer expression. This is the number of registers in the block to read.
unit_id	an integer expression that evaluates between 1 and 254. This is the unit number of the Boss Bear to read from. Each unit in the network must have a unique number.
source_reg	an integer expression. This is the first register number to read from the source unit.
status	an integer variable. This will hold the status of the NETWORK operation; a 0 will indicate successful completion, while a nonzero value will indicate that an error occurred.

Description:

The NETWORK 2 statement is used to transfer data from another unit on the network. It reads a block of network registers from the source Boss Bear to a register block in this unit. The next time that the network master polls this unit, a register request is transferred; when the destination unit receives the request, it will return the register data, and this statement will return. It will wait for at least five seconds for a response before timing out and returning an error; in a multitasking program, it may take longer than five seconds to time out, perhaps as much as 30 seconds or more.

It is often useful to read a register from a different register number in the source unit. The *dest_reg* and *source_reg* fields determine which registers are read and where they are stored in this unit. For example, `NETWORK 2,0,12,2,3,36,ST` will read INTEGER registers 36 and 37 from unit 3 and store them in INTEGER registers 12 and 13 in this Boss Bear. Of course, a register can be read from the same register number; for example, `NETWORK 2,1,7,1,2,7,ST` will read REAL register number 7 from unit 2 and store it in REAL register 7 in this Boss Bear.

No range checking is performed. If an attempt is made to read from a register that does not exist, then invalid data will be transferred. If an attempt is made to store into a register that does not exist, then other registers will be overwritten and unpredictable operation may occur.

This statement may not be used concurrently in a multitasking program; in other words, it can't be called from two tasks at the same time. It is highly recommended that all NETWORK 1 and NETWORK 2 statements be located in the same task.

Example:

```
100  INTEGER J, K, ST
110  NETWORK 0,1,20,30,0,ST          ' Initialize the network
120  IF ST THEN PRINT "Init Error"
130  FOR J=0 TO 19
140    NETWORK 3,0,J,0,ST            ' Zero out registers 0..19
150  NEXT J
160  NETWORK 2,0,0,20,2,0,ST         ' Read integer registers from unit 2
170  IF ST THEN PRINT "Timeout"
180  FOR J=0 TO 19
190    NETWORK 4,0,J,K,ST            ' K = register J value
200    PRINT J,K
210  NEXT J
220  NETWORK 2,0,18,1,3,28,ST        ' Read reg 28 from unit 3 into reg 18
230  IF ST THEN PRINT "Timeout"
240  NETWORK 4,0,18,K,ST
250  PRINT "Register 18 = "; K
```

In line 110, the network driver is initialized to unit 1 with 20 INTEGER registers, 30 REAL registers, and 0 STRING registers. In lines 130 to 150, the 20 integer registers (0 to 19) are filled with 0. In line 160, all 20 integer registers are read from the same registers in unit 2. Lines 180 to 210 print out the 20 values just read. In line 180, integer register 18 is read from unit 3, register 28; this value is printed in lines 230 and 240. Note that in line 160 we are assuming that unit 2 has at least 20 integer registers are available, and in line 180 we are assuming that unit 3 has at least 28 integer registers available.

Related topics:

NETWORK 0, NETWORK 1, NETWORK 3, NETWORK 4, Chapter 10

NETWORK 3 Statement

Summary:

The NETWORK 3 statement writes data into a network register.

Syntax:

NETWORK 3, *vartype*, *regnum*, *value*, *status*

Arguments:

vartype	an integer value of 0, 1, or 2. This indicates the type of network register to read: 0 for INTEGER, 1 for REAL, and 2 for STRING.
regnum	an integer expression. This is the register number to be written to.
value	an numeric or string expression. This is the value to be written to *regnum*.
status	an integer variable. This will hold the status of the NETWORK operation; a 0 will indicate successful completion, while a nonzero value will indicate that an error occurred.

Description:

The network registers are stored in an area that is normally inaccessible to the BASIC program as variable space. The NETWORK 3 statement writes data into a network register. This does not cause the data to be sent over the network, however. Data is only transferred when this unit performs a NETWORK 1 statement, another Boss Bear performs a NETWORK 2 statement, or the network master reads or writes data in the register. There are three sets of network registers, INTEGERs, REALs, and STRINGs; the number of each of these is set up with the NETWORK 0 statement. Each group of registers is numbered starting at 0; for example if there is a `NETWORK 0,1,25,15,5,ST` statement, then there are 25 INTEGER registers (numbered 0 to 24), 15 REAL registers (0 to 14), and 5 STRING registers (0 to 4). If an attempt is made to write outside of these ranges, then an error will be returned; for example, `NETWORK 3,0,30,99,ST` would return an error (ST will be nonzero) because only 25 INTEGER registers were declared above.

Example:

```
100  INTEGER J, K, ST
110  NETWORK 0,1,20,30,0,ST          ' Initialize the network
120  IF ST THEN PRINT "Init Error"
130  FOR J=0 TO 19
140    NETWORK 3,0,J,J+100,ST        ' Store 100..119 in registers 0..19
150  NEXT J
```

Related topics:

NETWORK 0, NETWORK 1, NETWORK 2, NETWORK 4, Chapter 10

NETWORK 4 Statement

Summary:

The NETWORK 4 statement reads data from a network register.

Syntax:

NETWORK 4, *vartype*, *regnum*, *variable*, *status*

Arguments:

vartype	an integer value of 0, 1, or 2. This indicates the type of network register to read: 0 for INTEGER, 1 for REAL, and 2 for STRING.
regnum	an integer expression. This is the register number to be read from.
variable	a numeric or string variable. The value read from *regnum* will be stored in this variable.
status	an integer variable. This will hold the status of the NETWORK operation; a 0 will indicate successful completion, while a nonzero value will indicate that an error occurred.

Description:

The network registers are stored in an area that is normally inaccessible to the BASIC program as variable space. The NETWORK 4 statement reads data from a network register into a BASIC variable. There are three sets of network registers, INTEGERs, REALs, and STRINGs; the number of each of these is set up with the NETWORK 0 statement. Each group of registers is numbered starting at 0; for example if there is a `NETWORK 0,1,25,15,5,ST` statement, then there are 25 INTEGER registers (numbered 0 to 24), 15 REAL registers (0 to 14), and 5 STRING registers (0 to 4). If an attempt is made to read outside of these ranges, then an error will be returned; for example, `NETWORK 4,0,30,J,ST` would return an error (ST will be nonzero) because only 25 INTEGER registers were declared above.

Example:

```
100  INTEGER J, K, ST
110  NETWORK 0,1,20,30,0,ST         ' Initialize the network
120  IF ST THEN PRINT "Init Error"
130  FOR J=0 TO 19
140    NETWORK 4,0,J,K,ST           ' Read registers 0..19
150    PRINT J,K
160  NEXT J
```

Related topics:

NETWORK 0, NETWORK 1, NETWORK 2, NETWORK 3, Chapter 10

NEW Direct Command

Summary:
The NEW direct command erases the program currently in memory.

Syntax:
NEW

Arguments:
NEW needs no arguments.

Description:
NEW erases the BASIC source code that is currently in memory. It enables runtime error checking, clears the duplicate line numbers flag, and erases the compiled code.

Related topics:
ERROR, DOWNLOAD, GO

NEXT Statement

Summary:

The NEXT statement marks the end of a FOR...NEXT control structure.

Syntax:

NEXT

Arguments:

variable an integer or real variable. This must match the variable referenced in the corresponding FOR statement.

Description:

See the FOR statement for a description of the FOR...NEXT control structure.

Related topics:

FOR

NOERR Direct Command

Summary:
The NOERR direct command disables the runtime error checking.

Syntax:
NOERR

Arguments:
NOERR needs no arguments

Description:
NOERR turns off much of the runtime error checking of Bear BASIC, resulting in a program that runs much faster, and takes less memory. To insure that a program doesn't run wild and destroy itself, Bear BASIC inserts quite a lot of error checking code into the compiled program. For example, tests are made for "SUBSCRIPT OUT OF RANGE", "NEXT WITHOUT FOR", etc. NOERR also removes the test for a CTRL-C. (CTRL-C aborts a running program, so a program compiled under NOERR can't be killed.) Most of these tests are removed by specifying NOERR. Some error checking routines remain, since in some cases the error checking code does not greatly effect execution speed. An increase in execution speed of several hundred percent can often be realized by using NOERR. The compiled program will also be significantly shorter. Be warned, though- NOERR permits the user's program to execute erroneously, possibly trashing Bear BASIC. Only fully debugged programs should be compiled under NOERR. When the compiler starts, all error checking is enabled and remains on until NOERR is specified. NOERR affects the way a program is compiled, so it must be specified before the program is COMPILEd or RUN.

Related topics:
ERROR, COMPILE, RUN, GO

ON ERROR Statement

Summary:

The ON ERROR statement traps I/O errors.

Syntax:

ON ERROR *linenum*

Arguments:

linenum a valid BASIC line number. This must be a line number that is in task 0 (ie. before the TASK 1 statement in the program).

Description:

ON ERROR causes the execution of the program to transfer to *linenum* when an I/O error is detected. ON ERROR is limited to operation in task 0. Both the function (or statement) that encounters the error and *linenum* must be before the TASK 1 statement.

Example:

```
100  INTEGER K
110  ON ERROR 900                    ' Set up error handler
120  K=GET                           ' Get a character from COM1
130  PRINT CHR$(K);                  ' Echo the character
140  WAIT 10: GOTO 120               ' Do it again
900  ' Error handler
910  FILE 6                          ' Display error on LCD/VFD
920  PRINT "Error ";ERR;" detected" ' Print error number
930  FILE 0: GOTO 120                ' Back to COM1 and continue above
```

This example will get bytes from COM1 and echo them back on COM1 at a rate of 10 per second. If an I/O error occurs, then execution will transfer to line 900, where it will display the error number on the onboard display, then jump back to line 120.

Related topics:

ERR, JVECTOR, Chapter 11

ON GOSUB Statement

Summary:

The ON GOSUB statement calls one of a number of subroutines based on the value of an expression.

Syntax:

ON *expr*, GOSUB *linenum* [,*linenum*]...

Arguments:

expr	an integer expression between 1 and the number of line numbers specified in the statement.
linenum	a valid BASIC line number.

Description:

ON GOSUB causes the program to GOSUB to a line number based on the value of *expr*, which must evaluate to a number from 1 to the number of line numbers given in the statement. If *expr* evaluates to 1, then the program branches to the first line number. If it is 2, then the program branches to the second line number, and so on. If *expr* evaluates to a number larger or smaller than the number of line numbers given, then the error message `Line Number Does Not Exist` will appear.

Example:

```
100  INTEGER J
110  PRINT "Enter a number (1 to 5) > ";
120  FINPUT "U1", J
130  PRINT
140  ON J, GOSUB 200,300,400,500,600
150  GOTO 110
200  PRINT "Line 200": RETURN
300  PRINT "Line 300": RETURN
400  PRINT "Line 400": RETURN
500  PRINT "Line 500": RETURN
600  PRINT "Line 600": RETURN
```

This example calls a subroutine based on the number entered by the user in line 120. Note that there is no range checking on the value entered, so it is possible to enter a number greater than 5, which will cause an error to occur.

Related topics:

ON GOTO, GOSUB, GOTO

ON GOTO Statement

Summary:

The ON GOTO statement jumps to line number based on the value of an expression.

Syntax:

ON *expr*, GOTO *linenum* [,*linenum*]...

Arguments:

expr	an integer expression between 1 and the number of line numbers specified in the statement.
linenum	a valid BASIC line number.

Description:

ON GOTO causes the program to GOTO to a line number based on the value of *expr*, which must evaluate to a number from 1 to the number of line numbers given in the statement. If *expr* evaluates to 1, then the program branches to the first line number. If it is 2, then the program branches to the second line number, and so on. If *expr* evaluates to a number larger or smaller than the number of line numbers given, then the error message `Line Number Does Not Exist` will appear.

Example:

```
100  INTEGER J
110  PRINT "Enter a number (1 to 5) > ";
120  FINPUT "U1", J
130  PRINT
140  ON J, GOTO 200,300,400,500,600
150  STOP
200  PRINT "Line 200"
300  PRINT "Line 300"
400  PRINT "Line 400"
500  PRINT "Line 500"
600  PRINT "Line 600"
```

This example jumps to a line based on the number entered by the user in line 120. Note that there is no range checking on the value entered, so it is possible to enter a number greater than 5, which will cause an error to occur.

Related topics:

ON GOSUB, GOTO, GOSUB

OUT Statement

Summary:
The OUT statement writes a value to a hardware output port.

Syntax:
OUT *port*, *value*

Arguments:
port an integer expression between 0 and 255. The hardware port number to read from.

value an integer expression between 0 and 255. The value to write to the port.

Description:
The Boss Bear processor interfaces with the real world through Input/Output (I/O) devices. The Boss Bear architecture supports both memory mapped devices, which are accessed using PEEK and POKE, and I/O mapped devices, which are accessed using INP and OUT. It requires a thorough understanding of the Boss Bear hardware in order to use INP and OUT; usually, the only time that these would be used is when copying example code supplied by Divelbiss in an application note.

OUT writes a single byte to an output port. If there is no hardware device at *port*, then this will have no effect.

Example:
```
100  OUT $80, $F7
```

Related topics:
INP, Chapter 7

PEEK Function

Summary:

The PEEK function reads a byte value from the specified address.

Syntax:

x = PEEK (*logaddr*)

Arguments:

logaddr an integer expression. The logical address to read from.

Description:

The PEEK function returns an integer from 0 through 255 that is the byte value at memory location *logaddr*. Normally, this reads from the 64KB address space that the BASIC program is running in. However, DEFMAP can be used to allow access to the entire 1MB physical address space; see DEFMAP for a complete explanation.

Example:

```
100  INTEGER K
110  POKE $A000,$12                ' Write a $12 into $A000
120  PRINT "$A000=";PEEK($A000)
130  K=500
140  FPRINT "H2",PEEK(ADR(K))      ' Print the low byte of K
150  FPRINT "H2",PEEK(ADR(K)+1)    ' Now print the high byte of K
```

This produces the following output when run:

```
$A000=18
F4
01
```

Line 120 prints `$A000=18` because 18 is the decimal equivalent of $12. Line 140 reads the low byte of the variable K; K is 500 ($1F4), so this prints "F4". Line 160 reads the high byte of K, which is 1.

Related topics:

POKE, WPOKE, WPEEK, EEPOKE, EEPEEK, DEFMAP

POKE Statement

Summary:
The POKE statement writes a byte value to the specified address.

Syntax:
POKE *logaddr*, *value*

Arguments:
logaddr an integer expression. The logical address to write to.
value an integer expression between 0 and 255. The value to write.

Description:
The POKE statement writes a byte (*value*) into memory at *logaddr*. Normally, this writes into the 64KB address space that the BASIC program is running in. However, DEFMAP can be used to allow access to the entire 1MB physical address space; see DEFMAP for a complete explanation.

Example:
```
100  INTEGER J,K
110  POKE $A000,$12                ' Write a $12 into $A000
120  PRINT "$A000=";PEEK($A000)
130  J=0: K=500
140  POKE ADR(K),J                 ' Write a $00 into low byte of K
150  PRINT K
160  POKE ADR(K)+1,J               ' Now write to high byte of K
170  PRINT K
```

This produces the following output when run:

```
$A000=18
256
0
```

Line 120 prints `$A000=18` because 18 is the decimal equivalent of $12. Line 140 stores a 0 into the low byte of the variable K; K was originally 500 ($1F4), so this changes it to 256 ($100). Line 160 stores a 0 into the high byte of K.

Related topics:
PEEK, WPOKE, WPEEK, EEPOKE, EEPEEK, DEFMAP

PRINT Statement

Summary:
The PRINT statement sends output to the current FILE device.

Syntax:
PRINT *expr* [;*expr*]...[;]

Arguments:
expr a numeric or string expression.

Description:
PRINT outputs data in a human-readable form to the current FILE device, as set by the last FILE statement executed. The console (FILE 0, COM1) is the default FILE. Commas or semicolons may separate *expr* values. A comma causes *expr* to be printed at the next tab stop; tab stops are 16 characters wide. A semicolon causes *expr* to be printed without inserting any extra spaces; if the last thing on the PRINT line is a semicolon, then no carriage return or line feed will be printed. The question mark can be used as an abbreviation for PRINT when typing in a program; the '?' will be replaced with PRINT when the program is LISTed.

Integer numbers are printed using the minimum number of characters. Real numbers are printed with 5 digits to the right of the decimal point.

PRINT should not be used in an interrupt task, because it re-enables interrupts and allows multitasking to continue. Depending upon what the other tasks are doing at the instant that the interrupt task executes, PRINT could cause the system to lock up.

Example:
```
100  INTEGER J: REAL X: STRING A$
120  J=12: X=1.234
130  PRINT "Boss Bear"
140  PRINT "Integrated "; "controller"
150  PRINT "J = "; J, "X = "; X
160  PRINT "Tan(X) = ";TAN(X)
170  A$="ABCDEFGHIJK"
180  PRINT A$;"  ";
190  PRINT MID$(A$,2,3)
```

Line 140 uses the semicolon (';') to cause the two strings to be printed together; note that the first string ends with a space. Line 160 shows the use of PRINT with an expression; the expression is evaluated and the result is printed. Line 180 ends with a semicolon, which causes the following PRINT (line 190) to appear on the same line. This produces the following output when run:

```
Boss Bear
Integrated controller
J = 12         X = 1.23400
Tan(X) = .02154
ABCDEFGHIJK  BCD
```

Related topics:

FPRINT

PRIORITY Statement

Summary:

The PRIORITY statement controls the order of execution of tasks in a multitasking program by setting a priority level for the current task.

Syntax:

PRIORITY *pri_num*

Arguments:

pri_num an integer expression between 0 and 127. This is the priority level to assign to the current task.

Description:

The PRIORITY statement assigns a priority level to a task. It is used to alter the manner in which tasks are executed. It allows the user to assign a priority, or degree of importance, to a task. PRIORITY is useful only in multitasking programs. The PRIORITY statement must be issued from within the task whose priority level is to be altered.

PRIORITY takes one argument, which is the relative priority level for that task. The larger the number, the more important the task is. These numbers may range from 0 to 127. Therefore, 0 is least important, and 127 is most important. Note that Bear BASIC assumes all tasks run at priority level 0 if no PRIORITY statement is issued.

In a multitasking program with no PRIORITY statements, each task is executed in a "round robin" fashion. This means that upon receipt of a tic, Bear Basic stops running the current task and starts running the next sequential task, if it is ready to be run. PRIORITY can be used to alter this sequence.

Whenever a tic is received, Bear Basic examines the priority levels of all tasks that are ready to execute. The first highest priority task is then run. This means that if task 1 is level 2, task 2 is level 3, and task 3 is level 3, then task 2 will run until it completes. If all the tasks have the same priority level, than the lowest number task that is ready to run will continue to run until it relinquishes control (by executing EXIT, WAIT, INPUT, etc.). If the task with the highest priority level does not EXIT or WAIT, then it will use all of the computer time, effectively disabling multitasking, until it EXITs, goes into a WAIT, or reduces its priority level.

Bear Basic reevaluates the priorities on each tic, so tasks can dynamically change their level and the compiler will alter the scheduling as demanded.

Whenever a CANCEL statement is encountered, the priority level for that task is dropped to 0. This yields faster context switching.

Example:

```
100  RUN 1,10
110  RUN 2,20
120  GOTO 30
130  TASK 1
140  PRIORITY 3
150  PRINT 'Task 1'
160  EXIT
170  TASK 2
180  PRINT 'Task 2'
190  EXIT
```

This program shows task 1 issuing a PRIORITY 3. This means that if this task is ready to run, and if task 2 is also ready, then task 1 will execute first, and will continue to execute until it is complete. When it is done, task 2 will run, since task 1 has been told to wait 10 tics (via the RUN statement in line 10) before starting again.

Related topics:

EXIT, WAIT, CANCEL

RANDOMIZE Statement

Summary:

The RANDOMIZE statement reseeds the random number generator.

Syntax:

RANDOMIZE

Arguments:

RANDOMIZE needs no arguments.

Description:

The RND function generates pseudo-random numbers, which means that they are generated by a mathematical algorithm. This algorithm starts with a seed number; the first call to RND returns a number that is based on this seed. Each succeeding number is based on the previous number, and becomes the new seed. The RANDOMIZE statement changes the seed value by reading the processor refresh register, which provides a constantly changing value.

Example:

```
100  INTEGER J
110  RANDOMIZE                      ' Reseed the random number generator
120  FOR J=1 TO 20
130    FPRINT "U2X3U5",J,RND        ' Print 20 random numbers
140  NEXT J
```

Related topics:

RND

RDCNTR Statement

Summary:

The RDCNTR statement reads the count value from the high speed counter. It also can reset the counter's high speed output.

Syntax:

RDCNTR *chan*, *flag*, *variable*

Arguments:

chan an integer expression between 1 and the number of counter channels installed. This is the counter channel to read.

flag an integer expression from 0 through 3. This determines whether to read the current count or latched count, and whether or not to reset the high speed output:

- 0 to latch and read the current count.
- 1 to read only the last latched count value; this is used to read a value that was latched when the marker input was activated.
- 2 to latch and read the current count; also reset the high speed output.
- 3 to read only the last latched count value; also reset the high speed output.

variable an integer or real variable. The count value will be stored in this variable. If it is an integer, then only the least significant 16 bits of the 24 bit count value will be used. If it is a real, then all 24 bits will be stored.

Description:

The RDCNTR statement reads the one of the counter's registers, and optionally resets the high speed output. The counter hardware provides two 24 bit count registers: one holds the current count, and one holds the count value when the latch input was activated. In order to read the current count, the hardware first loads it into the latched count register.

The counter channels are assigned based on the hardware available on the Boss Bear; channel 1 could be the onboard counter, or in any of the expansion ports (if there is no onboard counter. The order of precedence for assigning counter channels is: onboard counter followed by J3 followed by J4 followed by J5.

The counter automatically wraps around when it reaches the 24 bit limit ($FFFFFF). When it is read as an integer value, it will wrap from 32767 back to -32768, or from -32768 to 32767 if counting down. When it is read as a real value, it will wrap from 8388607.0 to -8388608.0, or from -8388608.0 to 8388607.0 if counting down.

Care must be exercised when accessing the counter using real values, because the roundoff error associated with real numbers may affect the operation of the counter. If real values are to be used, then it will be simpler if the counter is not allowed to go above about 4000000.0 or below about -4000000.0; for instance, the counter should be set to 0 periodically, such as at the end of a batch or the end of a shift.

Examples:

```
100  INTEGER COUNTI: REAL COUNTR
120  CNTRMODE 1,4                    ' A count, B direction
130  WRCNTR 1,0,65500.0              ' Set count to 65500
140  ' Main program loop
150  RDCNTR 1,0,COUNTI               ' Read current count as integer
160  RDCNTR 1,0,COUNTR               ' Read current count as real
170  PRINT COUNTI,COUNTR
180  WAIT 10: GOTO 150
```

This example demonstrates reading counter 1 with both integer and real variables. It simply sits in a loop, reading and displaying the counter value. Note that when the counter passes 65535, the values of COUNTI and COUNTR will be different because COUNTI only holds the least significant 16 bits of the counter value.

Related topics:

CNTRMODE, WRCNTR, Chapter 7

READ Statement

Summary:

The READ statement loads variables with values stored in DATA statements.

Syntax:

READ *variable* [,*variable*]...

Arguments:

variable an integer, real, or string variable name. The next DATA item will be stored in this variable.

Description:

READ loads the variables in its argument list with values from DATA statements. As successive READs are executed, data is taken from each DATA statement in the program. All DATA statements must appear before the first READ in the program.

Example:

```
100  INTEGER J,K
110  REAL X
120  STRING A$
130  PRINT "DATA statement example"
140  ' Data table for program
150  DATA 4.77,2,3,4,5,23,83,8            ' Must be before first READ
160  DATA 999,3.14159,1.6667
170  DATA 893.664,999,"Data 1"
180  DATA "This is a test: Hi, everybody"
190  FOR J=1 TO 3
200    READ K: PRINT K                     ' Print first 3 elements
210  NEXT J
220  READ J
230  IF J<>999 THEN PRINT J: GOTO 220      ' Print elements until a 999
240  READ X
250  IF X<999.0 THEN PRINT X: GOTO 240     ' Print elements until a 999
260  READ A$: PRINT A$                     ' Print first string
270  READ A$: PRINT A$                     ' Print second string
280  READ X: PRINT X                       ' Wrap around, do first one again
```

This produces the following output when run:

```
DATA statement example
4
2
3
4
5
23
83
8
3.14159
1.66670
893.66381
Data 1
```

```
This is a test: Hi,
4.77000
```

The two 999 values in lines 160 and 170 are used as flags to indicate the end of portions of the table; this makes it easy to add to the DATA table without needing to change the program where the READ statements are executed. In line 270, it prints "This is a test: Hi, " because the string variable A$ defaults to 20 character maximum length, so it truncates the rest of the string when it is read. Note that in line 280, it reads beyond the end of the DATA table, so it wraps around and reads the first value in the table.

Related topics:

DATA, RESTORE

REAL Statement

Summary:

The REAL statement is used to declare floating point variables.

Syntax:

REAL *variable* [,*variable*]...

Arguments:

variable a text string. The name to use for the variable. Variable names in Bear BASIC consist of an alphabetic character followed by up to 6 alphanumeric characters. To declare an array, this will be followed by one or two numbers enclosed in parenthesis. The following are valid real variable names: J, J(20), PRESURE, CHAN5, TIME4(10), J(10,7).

Description:

Real variables are used to hold numeric data that ranges between -1.7×10^{38} and 1.7×10^{38}. Reals are stored in 32 bit IEEE single precision format, taking up 4 bytes. All variables in a Bear BASIC program must be declared as INTEGER, REAL, or STRING; all variable declarations must occur before any executable statements in the BASIC program.

Real arrays may be declared with the REAL statement, as well. Bear BASIC allows one and two dimensional arrays. The variable name is followed by parenthesis enclosing one or two array dimensions, such as J(5) or J(7,5). Note that the array dimension is not the number of array elements, but the number of the last array element; arrays always start with element 0. The array J(5) actually contains 6 variables, J(0) through J(5).

Approximately 6.5 digits of precision are maintained for real numbers. Many BASIC interpreters and compilers use BCD mathematics or 64 bit representations resulting in high accuracy numbers that require lots of memory. Bear BASIC does not support either of these in the interest of maximizing speed. The user must be aware that a real number may not be exactly the number anticipated. For example, since real numbers are constructed by using powers of 2, the value 0.1 cannot be exactly represented. It can be represented very closely (within 2**-23, or about 0.0000001), but it will not be exact. Therefore, it is very dangerous to perform a direct equality operation on a real number. The statement `IF A=0.123` (assuming A is real) will only pass the test if the two values are exactly equal, a case which rarely occurs. This is true for all real relational operators, including, for example, the statement `IF A>B`, if values very close to the condition being measured are being used. Be aware that the number you expect may not be exactly represented by the compiler. If necessary, use a slight tolerance around variables with relational operators.

Example:

```
100  INTEGER J
110  REAL X
110  REAL CHAN(9)                    ' Array of 10 integers: 40 bytes
120  REAL TDAT(4,19)                 ' 5 by 20 array: 400 bytes
130  FOR J=0 TO 9
140    CHAN(J)=J                     ' Shows how arrays are accessed
150    TDAT(0,J)=J*1.234
160  NEXT J
```

Related topics:

INTEGER, STRING

REM Statement

Summary:

The REM statement is used to mark the rest of the line as comment text.

Syntax:

REM *text*

Arguments:

text any text string.

Description:

The REM statement allows the programmer to put informational comments (also called remarks) into the BASIC program. The compiler disregards anything between a REM statement and the end of the line, including the colon (:). Comment text increases the size of the BASIC source code, but does not increase the size of the compiled code. REM is equivalent to ! and ', which also mark comment text; REM statements will be displayed as single quotes (') when the program is LISTed.

Example:

```
100  REM This program demonstrates the REM statement
110  INTEGER J: REM Declare an integer : this is still a comment
120  J=3600       ' This comment starts with the quote character
130  J=J/3        ' Note that there doesn't have to be a colon before the quote
140               ! This comment starts with the exclamation point
```

If this example were typed in (or downloaded) exactly as shown above and then LISTed, it would be displayed like this:

```
100  ' This program demonstrates the REM statement
110  INTEGER J: ' Declare an integer : this is still a comment
120  J=3600: ' This comment starts with the quote character
130  J=J / 3: ' Note that there doesn't have to be a colon before the quote
140  ' This comment starts with the exclamation point
```

RESTORE Statement

Summary:

The RESTORE statement resets the DATA pointer to the first DATA statement in the program.

Syntax:

RESTORE

Arguments:

RESTORE needs no arguments.

Description:

As READ statements are executed to load values from DATA statements, a pointer is incremented to point to the succeeding DATA statement. RESTORE sets this pointer to the first DATA statement in the program. The next READ will load the first DATA item.

Example:

```
100  INTEGER J, K
110  DATA 1,2,3,4
120  DATA 5,6
130  FOR J= 1 to 5
140    READ K: PRINT K
150  NEXT J
160  RESTORE                          ' Set back to first DATA, which is 1
170  READ K: PRINT K
```

This produces the following output when run:

```
1
2
3
4
5
1
```

Related topics:

DATA, READ

RETURN Statement

Summary:
The RETURN statement ends a subroutine started by a GOSUB.

Syntax:
RETURN

Arguments:
RETURN needs no arguments.

Description:
The RETURN statement causes program execution to continue at the statement following the GOSUB that called the subroutine containing the RETURN. If a RETURN is encountered without a corresponding GOSUB, then the error message `RETURN Without GOSUB` will be displayed.

Example:
```
100  GOSUB 200: PRINT "We're back"  ' Call subroutine at line 200
110  STOP                           ' Don't fall into subroutine
200  PRINT "Line 200"
210  RETURN                         ' Return from subroutine
```

This example just calls a subroutine and displays messages to indicate what is being executed. Line 110 is needed so that it doesn't continue executing and fall into line 200, which would generate an error when it got to line 210. Try removing line 110 and running the program.

Related topics:
GOSUB

RND Function

Summary:
The RND function returns a pseudo-random integer.

Syntax:
x = RND

Arguments:
RND needs no arguments.

Description:
The RND function generates pseudo-random numbers, which means that they are generated by a mathematical algorithm. It returns an integer value between -32768 and 32767. This algorithm starts with a seed number; the first call to RND returns a number that is based on this seed. Each succeeding number is based on the previous number, and becomes the new seed. The seed may be initialized using the RANDOMIZE statement.

Example:
```
100  INTEGER J
110  RANDOMIZE
120  FOR J=1 TO 32
130  FPRINT "I10Z",RND
140  NEXT J
150  PRINT
```

This produces the following output when run:

```
 11546    28119    11026   -19169   -21366    11495    10626   -25297
-26118    19959    30194     1855   -19094     4359   -12190    13135
-16678   -18921    -1838    24927    30282    32039   -20670   -11921
-25670   -22985   -19534   -15489    -4310    28999   -14814    30607
```

Related topics:

RUN Direct Command

Summary:
The RUN direct command compiles and executes a program.

Syntax:
RUN

Arguments:
RUN needs no arguments.

Description:
RUN compiles the BASIC program in memory. If no errors are detected, then it executes the program. It can take up to 20 seconds to compile a long program.

Related topics:
COMPILE, GO

RUN Statement

Summary:
The RUN statement starts execution of a task in a multitasking program.

Syntax:
RUN *task* [,*resched*]

Arguments:
task an integer expression from 1 through 31. The task number to begin executing.

resched an integer expression from 1 through 32767. The reschedule interval for *task*. If this isn't specified, then the reschedule interval for the task is undefined.

Description:
The RUN statement makes a task ready to run, so that the context switcher will execute it at some future time. If the task EXITs, then it will be rescheduled to start executing again after *resched* tics have elapsed; this provides a convenient way of making something happen periodically.

The RUN statement should not be used if the task is already executing. This will cause the task to be restarted at the beginning, regardless of where it is currently executing. This would cause erratic operation of the task.

Examples:
```
100  RUN 1,100                      ' Start task 1 running, resched once/second
110  GOTO 110                       ' Loop forever
200  TASK 1
210  PRINT "Task 1 running"
220  EXIT
```
Line 100 sets up task 1 to start running with a reschedule interval of 100 tics, or once per second. The main program then sits in a loop forever. When task 1 runs, it prints a message then EXITs, which causes it to be rescheduled for 100 tics later.

```
100  RUN 1,100                      ' Start task 1 running, resched once/second
110  GOTO 110                       ' Loop forever
200  TASK 1
210  PRINT "Task 1 running"
220  GOTO 210                       ' Loop and print again
```
The difference between this example and the previous one is in line 220. In the second example, task 1 doesn't EXIT, but instead just loops and prints the message again. Since it doesn't EXIT, the reschedule interval has no effect, so line 100 could have just been RUN 1.

Related topics:
EXIT, CANCEL

SAVE Direct Command

Summary:

The SAVE direct command saves the BASIC source or compiled code that is in memory to the user's EPROM.

Syntax:

SAVE [CODE] [*filename*]

Arguments:

filename a text string, up to 10 characters long. The filename to be stored on the EPROM. The name will be stored in uppercase, even if it is entered in lowercase.

Description:

SAVE stores the current BASIC source program onto the user's EPROM. SAVE CODE stores the current compiled code onto the user's EPROM. If *filename* is specified, then it is stored with the file. The file name for a source program is just used as a comment, to indicate what the program does. With compiled code, however, the file's name can be used with the CHAIN statement. It is possible to have more than one file on an EPROM with the same name; these files will be differentiated by their file numbers. SAVE is identical to EPROM SAVE.

Example:

`SAVE`	Saves the BASIC source with no filename.
`SAVE CODE`	Saves compiled code with no filename.
`SAVE Program1`	Saves the BASIC source as PROGRAM1.
`SAVE CODE test`	Saves compiled code as TEST.

Related topics:

LOAD, EPROM SAVE, EPROM LOAD

SERIALDIR Statement

Summary:

The SERIALDIR statement sets the direction and RTS level of the serial ports.

Syntax:

SERIALDIR *file*, *direction*

Arguments:

file an integer expression. The file number of the serial port: 0 for COM1, 5 for COM2.

direction an integer expression. 0 for receive and 1 for transmit.

Description:

For an RS-232 serial port, SERIALDIR sets the RTS output level. For an RS-422 serial port, SERIALDIR enables and disables the transmitter (0=disabled, 1=enabled). For an RS-422 serial port, SERIALDIR sets the direction of the port (0=receive, 1=transmit).

Upon power-up, the hardware sets the RTS active for RS-232 ports, and sets the transmitter off for RS-422 and RS-485 ports.

Boss Bear: This currently isn't implemented on the Boss Bear.

Example:

```
100  SERIALDIR 0,1                  ' Set COM1 RTS inactive
110  SERIALDIR 5,0                  ' Set COM2 to receive mode
```

Related topics:

Chapter 7, Appendix H

SETDATE Statement

Summary:

The SETDATE statement sets the current date on the Real Time Clock.

Syntax:

SETDATE *month*, *day*, *year*, *wday*

Arguments:

month	an integer expression. The month in the year, represented as 1-Jan, 2-Feb, ..., 12-Dec.
day	an integer expression. The day of the month, represented as 1..31.
year	an integer expression. The year, represented as 0..99.
wday	an integer expression. The day of the week, represented as 1-Sunday, 2-Monday, ..., 7-Saturday. This value is not stored on the UCP, but an expression must still be supplied to avoid generating a syntax error.

Description:

SETDATE sets the current date on the Real Time Clock. Note that the Real Time Clock is an option on the Boss Bear. SETDATE takes about 200 microseconds to execute.

UCP: The UCP uses a Touch Memory device for the real time clock. The SETDATE statement takes about 150 milliseconds to execute on the UCP, which is much longer than the Boss Bear.

Example:

```
100  SETDATE 4,1,91,2              ' Set Monday, April 1, 1991
```

Related topics:

GETDATE, GETIME, SETIME

SETIME Statement

Summary:

The SETIME statement sets the current time on the Real Time Clock.

Syntax:

SETIME *hours*, *minutes*, *seconds*

Arguments:

hours	an integer expression. The hours, represented as 0..23, with 0 being midnight.
minutes	an integer expression. The minutes, represented as 0..59.
seconds	an integer expression. The seconds, represented as 0..59.

Description:

SETIME sets the current time on the Real Time Clock. Note that the Real Time Clock is an option on the Boss Bear. SETIME takes about 200 microseconds to execute.

UCP: The UCP uses a Touch Memory device for the real time clock. The SETIME statement takes about 150 milliseconds to execute on the UCP, which is much longer than the Boss Bear.

Example:

```
100  SETIME 14,23,45                ' Set time to 2:23:45 pm
```

Related topics:

GETIME, SETDATE, SETDATE

SETOPTION DAC Direct Command

Summary:

The SETOPTION DAC command sets the initial power-up value for a DAC output channel. The Boss Bear must have the optional EEPROM installed in order for this command to take effect.

Syntax:

SETOPTION DAC *chan*,*value*

Arguments:

chan	the DAC channel number, between 1 and 12.
value	the initial DAC value, between 0 and 1023.

Description:

Prior to version 2.03 of Bear BASIC, the DAC channels were not initialized when the Boss Bear was turned on, causing the DAC outputs to go to a random voltage. With version 2.03, the initial DAC values are stored in the reserved area of the EEPROM; when the Boss Bear is turned on, each DAC channel is set to the corresponding EEPROM value. These EEPROM values are set using the SETOPTION DAC command.

UCP: Because the DAC values on the UCP range from 0 to 32767, the *value* parameter should be 0 to 32767 for SETOPTION DAC on the UCP.

Examples:

```
SETOPTION DAC 1,512
```

This sets the EEPROM DAC table so that channel 1 will be set to 512 when the Boss Bear is turned on. If the DAC module is configured so that channel 1 is -5V to +5V, then this causes the output to be 0V at power-up, for example.

```
SETOPTION DAC 3,0
```

This causes DAC channel 3 to be initialized to 0. If channel 3 is configured as a 4-20mA current loop, then the output would be 4mA at power-up.

Related topics:

DAC, Chapter 7, Chapter 9, Appendix H

SIN Function

Summary:
The SIN function calculates the sine function.

Syntax:
x = SIN (*expr*)

Arguments:
expr a numeric expression.

Description:
The SIN function returns the sine of its argument, which must be a numeric expression, in degrees. The result is returned as a REAL value.

Example:
```
100  REAL X,Y
110  PRINT SIN(45.0)
120  X=68.3
130  Y=SIN(X)
140  PRINT "Sine value of ";X;" is ";Y
```

This produces the following output when run:

```
.70711
Sine value of 68.29999 is .92913
```

Related topics:
ASIN, COS, ACOS, TAN, ATAN

SQR Function

Summary:

The SQR function calculates the square root function.

Syntax:

x = SQR (*expr*)

Arguments:

expr a numeric expression.

Description:

The SQR function returns the square root of its argument, which must be a numeric expression. The result is returned as a REAL value.

Example:

```
100  REAL X,Y
110  PRINT SQR(2.0)
120  X=144.0
130  Y=COS(X)
140  PRINT "Square root of ";X;" is ";Y
```

This produces the following output when run:

```
1.41422
Square root of 144.00000 is 12.00000
```

Related topics:

COS, ACOS, SIN, ASIN, TAN, ATAN

STAT Direct Command

Summary:

The STAT direct command displays the Bear BASIC software version number and the memory usage of the last compiled program.

Syntax:

STAT

Arguments:

STAT needs no arguments.

Description:

The STAT command can be issued at any time. It displays the Boss Bear's software version number. It also displays the memory usage information for the last successfully compiled program; this information is always displayed, but it is only valid after a program has been successfully compiled. If a program was compiled and generated errors, then some of the numbers displayed by STAT may be incorrect.

Example:

STAT displays data such as the following:

`Start: 0100`	Starting address of program.
`End: 3EC4`	End address of program code.
`Variable: E0F6`	Starting address of program variables.
`27k Source Bytes Free`	Source code bytes free.
`40k Runtime Bytes Free`	Runtime bytes free.
`BEAR BASIC Compiler Version 2.00`	Boss Bear software version number.

Related topics:

COMPILE, RUN

STOP Statement

Summary:
The STOP statement stops execution of the program.

Syntax:
STOP

Arguments:
STOP needs no arguments.

Description:
STOP immediately stops execution of the program and returns to the compiler prompt.

Example:
```
100  PRINT "Line 100"
110  PRINT "Line 110"
120  STOP
130  PRINT "Line 130"
```

This produces the following output when run:

```
Line 100
Line 110
```

STR$ Function

Summary:
The STR$ function converts a number into a string.

Syntax:
*st$* = STR$ (*expr*)

Arguments:
expr a numeric expression.

Description:
The STR$ function returns a STRING result that is the human readable, decimal text representation of *expr*. It formats the result as a real number (ie. 12.34000, 5.00000, etc.). Remember that a number may have many different representations; for example, the decimal number 100 is represented in hexadecimal as $0064. The result of STR$(100) is a 9 character string: "100.00000".

Note that this is much different than MKI$ or MKS$, which convert a number into a binary string. Binary strings are not human readable, and in fact are just arrays of bytes.

Example:
```
100  INTEGER J: REAL X
110  STRING A$(60)
120  J=45: X=38.014
130  PRINT STR$(J)
140  A$=CONCAT$("The value of X is ",STR$(X))
150  PRINT A$
```

This produces the following output when run:

```
45.00000
The value of X is 38.01399
```

Related topics:
VAL

STRING Statement

Summary:

The STRING statement is used to declare string variables.

Syntax:

STRING *variable* [,*variable*]...

Arguments:

variable a text string. The name to use for the string variable. String variable names in Bear BASIC consist of an alphabetic character followed by up to 6 alphanumeric characters followed by a '$'. To declare an array, this will be followed by one or two numbers enclosed in parenthesis. The following are valid string variable names: A$, A$(20), NAME$, TIME4$(10), A$(10,7).

Description:

String variables are used to hold text data. All variables in a Bear BASIC program must be declared as INTEGER, REAL, or STRING; all variable declarations must occur before any executable statements in the BASIC program.

Variables in the STRING statement may have a maximum string length specified by enclosing the maximum length in parenthesis; no more than 127 may be specified. If no maximum is given, it will default to 20 characters. If an attempt is made to access beyond the end of the string, the error message `String Length Exceeded` will be displayed. A string array may be specified by giving two parameters enclosed in parenthesis: the first is the length of each element, and the second is the number of elements in the array. When accessing a string array, however, only one parameter is given inside the parenthesis; for example, if `STRING RL$(10,24)` is used to declare an array of 25 strings, each 10 characters long, then the 11th array element is accessed using `RL$(10)`.

Example:

```
100  INTEGER J
110  STRING A$                      ' 20 character string
120  STRING RDLIN$(80)              ' 80 character string
130  STRING DAY$(3,6)               ' Array of 7 strings, 3 chars long
140  DATA "Sun","Mon","Tue","Wed","Thu","Fri","Sat"
150  INPUT RDLIN$
160  A$=MID$(RDLIN$,5,8)
170  FOR J=0 TO 6
180    READ DAY$(J)                 ' Shows how arrays are accessed
190    PRINT DAY$(J)
200  NEXT J
```

Related topics:

REAL, STRING

SYSTEM Statement

Summary:

The SYSTEM statement is used to link Bear BASIC to an assembly language subroutine.

Syntax:

SYSTEM *addr*, *regarray*

Arguments:

addr a numeric expression. The address of the subroutine to call.

regarray an array of at least 4 integers. On entry, these hold the register values to pass to the subroutine. On return, these hold the register values passed back from the subroutine. The registers are formatted in the array as follows:

Array Element	High Byte	Low Byte
0	A	flags
1	B	C
2	D	E
3	H	L

Description:

The SYSTEM statement calls an assembly language subroutine, passing register values in an integer array. This is similar to the CALL statement, except that CALL passes the addresses of BASIC variables to the subroutine. To pass values to an assembly language subroutine, put the values into the correct spots in *regarray* and use SYSTEM to transfer to the subroutine, which will use the values in the registers as it needs them. When the subroutine executes a RET instruction ($C9), the current value of the registers will be passed back to the BASIC program.

Example:

```
100  INTEGER RA(3)
110  INTEGER J,K
200  DATA $3C                        ' INC A
205  DATA $04                        ' INC B
210  DATA $0C                        ' INC C
215  DATA $14                        ' INC D
220  DATA $1C                        ' INC E
225  DATA $24                        ' INC H
230  DATA $2C                        ' INC L
235  DATA $C9                        ' RET
300  '
305  ' Store the assembly language subroutine at address $8000
310  FOR J=0 TO 7
315    READ K
320    POKE J + $8000,K
330  NEXT J
350  RA(0)=$0001                     ' A = $00,  F = $01
360  RA(1)=$0203                     ' B = $02,  C = $03
370  RA(2)=$0405                     ' D = $04,  E = $05
380  RA(3)=$0607                     ' H = $06,  L = $07
400  SYSTEM $8000,RA(0)              ' Must specify RA(0)
410  ' Display return values from subroutine
420  FPRINT "H4X2H4X2H4X2H4",RA(0),RA(1),RA(2),RA(3)
```

This program stores an assembly language subroutine at location $8000 (in lines 310 to 330) and calls it with the SYSTEM statement (in line 400). The address $8000 was chosen because STAT indicated that the area from around $3C00 to around $E800 was unused, so an address in the middle of this range was picked. The subroutine just increments all of the registers (except the flags register) and returns. Lines 350 to 380 set the values to pass to the subroutine. Line 420 displays the return values from the subroutine. This produces the following output when run:

```
0101  0304  0506  0708
```

Related topics:

CALL, CODE, Appendix D

TAN Function

Summary:
The TAN function calculates the tangent function.

Syntax:
x = TAN (*expr*)

Arguments:
expr a numeric expression.

Description:
The TAN function returns the tangent of its argument, which must be a numeric expression, in degrees. The result is returned as a REAL value.

Example:
```
100  REAL X,Y
110  PRINT TAN(45.0)
120  X=68.3
130  Y=TAN(X)
140  PRINT "Tangent value of ";X;" is ";Y
```

This produces the following output when run:

```
1.00000
Tangent value of 68.29999 is 2.51288
```

Related topics:
ATAN, COS, ACOS, SIN, ASIN

TASK Statement

Summary:

The TASK statement marks the beginning of a task.

Syntax:

TASK *task*

Arguments:

task an integer number from 1 through 31. This is the number of the task in the program.

Description:

In a multitasking program, all tasks, other than task 0 (the main program), must begin with a TASK statement. The TASK statement must be at the start of a BASIC line; it cannot be in the middle of a multi-statement line. The tasks must be numbered sequentially starting at 1; the error message `Task Error` is displayed by the compiler if a task is numbered out of order.

Each task has its own set of temporary variables that are used by BASIC to perform operations; they must be separate so that a task doesn't corrupt other task's variables when it starts to execute. A task must not GOTO or GOSUB a line that is part of another task without taking special precautions; see Chapter 5 for further details.

Example:

```
100  RUN 1,100                      ' Start task 1, reschedule once/second
110  PRINT "Main program"
120  WAIT 90: GOTO 110
200  TASK 1                         ' Mark beginning of task 1
210  PRINT "Task 1"
220  EXIT
```

Related topics:

RUN statement, EXIT, WAIT, CANCEL

TMADDR Statement

Summary:

The TMADDR statement sets the ID for succeeding Touch Memory accesses.

Syntax:

TMADDR *idstr*

Arguments:

idstr Touch Memory ID stored in first 8 bytes of string.

Description:

After TMSEARCH is used to find the ID's of all attached Touch Memories, TMADDR specifies which Touch Memory to communicate with. After `TMADDR ID` is executed, all succeeding TMREAD and TMWRITE accesses will go to the Touch Memory with the specified ID. This is not currently implemented on the Boss Bear.

Example:

```
100  INTEGER NDEV, NUM, ST
110  STRING ID$(80), DAT$(30)
200  NDEV=TMSEARCH(ID$)                    ' Read device IDs.
210  IF NDEV=0 THEN WAIT 50: GOTO 200      ' Loop if none found.
220  FOR NUM=0 TO NDEV-1
230    TMADDR MID$(ID$,NUM*8+1,8)          ' Set up ID to write to.
240    ST=TMREAD(DAT$,0,20)                ' Zero out data at location 0.
250    PRINT ST,DAT$                       ' Display data.
260  NEXT NUM
```

Related topics:

TMSEARCH, TMREAD, TMWRITE

TMREAD Function

Summary:

The TMREAD function reads data from a Touch Memory device attached to the Touch Memory port.

Syntax:

stat=TMREAD(*datstr$*,*location*,*length*)

Arguments:

datstr$	string variable to store data into.
location	an integer expression. The starting byte location to read from within the Touch Memory.
length	an integer expression. The number of bytes to read from the Touch Memory.

Description:

TMREAD transfers data from a Touch Memory device into a BASIC string variable. It transfers *length* number of bytes starting at *location* in the Touch Memory.

Note that no range checking is performed on the *location* and *length* arguments. It is possible to read beyond the end of the Touch Memory device. This causes unpredictable values to be stored in *datstr$*. This is not currently being implemented on the Boss Bear.

Example:

```
100  INTEGER NDEV, NUM, ST
110  STRING ID$(80), DAT$(30)
200  NDEV=TMSEARCH(ID$)                    ' Read device IDs.
210  IF NDEV=0 THEN WAIT 50: GOTO 200      ' Loop if none found.
220  FOR NUM=0 TO NDEV-1
230    TMADDR MID$(ID$,NUM*8+1,8)          ' Set up ID to write to.
240    ST=TMREAD(DAT$,30,10)               ' Read bytes 30..39
250    PRINT ST,DAT$
260  NEXT NUM
```

Related topics:

TMADDR, TMSEARCH, TMWRITE

TMSEARCH Function

Summary:

The TMSEARCH function reads the ID string for all Touch Memory devices attached. It returns the number of devices found.

Syntax:

num=TMSEARCH(*idstr*)

Arguments:

idstr string variable to store any Touch Memory ID strings in.

Description:

Each Touch Memory device has a unique eight byte ID string stored permanently in it. In order to access the device, this ID must be sent as part of all commands. The TMSEARCH function scans the Touch Memory interface port, getting the ID strings for all attached Touch Memories. All of these ID strings are concatenated together in *idstr*. If two Touch Memories were found, for example, then *idstr* would be 16 characters long, with the first ID at the first character of the string, and the second ID starting at the eighth character of the string. This is not currently being implemented on the Boss Bear.

Example:

```
100  INTEGER NDEV, NUM, ST
110  STRING ID$(80), DAT$(30)
150  DAT$=""
160  FOR NUM=1 TO 30
170    DAT$=CONCAT$(DAT$,CHR$(0))         ' Build string of 0 bytes.
180  NEXT NUM
200  NDEV=TMSEARCH(ID$)                   ' Read device IDs.
210  IF NDEV=0 THEN WAIT 50: GOTO 200     ' Loop if none found.
220  FOR NUM=0 TO NDEV-1
230    TMADDR MID$(ID$,NUM*8+1,8)         ' Set up ID to write to.
240    ST=TMWRITE(DAT$,0)                 ' Zero out data at location 0.
250    PRINT "Write status=";ST
260  NEXT NUM
```

Related topics:

TMADDR, TMREAD, TMWRITE

TMWRITE Function

Summary:

The TMWRITE function writes data to a Touch Memory device attached to the Touch Memory port.

Syntax:

stat=TMWRITE(*datstr$*,*location*)

Arguments:

datstr$ string variable containing the data to write.

location an integer expression. The starting byte location to read from within the Touch Memory.

Description:

TMWRITE transfers data from a BASIC string variable into a Touch Memory device. It transfers *length* number of bytes starting at *location* in the Touch Memory.

Note that no range checking is performed on the *location* and *length* arguments. It is possible to attempt to write beyond the end of the Touch Memory device. This causes data to be lost, since the data that won't fit in the Touch Memory is discarded. This is not currently being implemented on the Boss Bear.

Example:

```
100  INTEGER NDEV, NUM, ST
110  STRING ID$(80), DAT$(30)
200  NDEV=TMSEARCH(ID$)                    ' Read device IDs.
210  IF NDEV=0 THEN WAIT 50: GOTO 200      ' Loop if none found.
220  FOR NUM=0 TO NDEV-1
230    TMADDR MID$(ID$,NUM*8+1,8)          ' Set up ID to write to.
240    DAT$="This is a test"
250    ST=TMWRITE(DAT$,73)                 ' Write to bytes 73..86
260    PRINT ST
270    ST=TMREAD(DAT$,73,14)
280    PRINT ST,DAT$
290  NEXT NUM
```

Related topics:

TMADDR, TMSEARCH, TMWRITE

TRACEON and TRACEOFF Statements

Summary:

The TRACEON and TRACEOFF statements enable and disable the line number trace, respectively.

Syntax:

TRACEON
TRACEOFF

Arguments:

TRACEON and TRACEOFF need no arguments.

Description:

TRACEON causes the line number of each line to print as it is executed; the line numbers are printed on the current FILE device. TRACEOFF disables the trace.

Example:

```
100  INTEGER J
110  TRACEON
120  FOR J=1 TO 3
130    PRINT "Number "; J
140  NEXT J
150  TRACEOFF
160  PRINT "Done"
```

This produces the following output when run:

```
120
130
Number 1
140
130
Number 2
140
130
Number 3
140
150
Done
```

Related topics:

DEBUG

VAL Function

Summary:
The VAL function converts a string into a number.

Syntax:
x = VAL (*strexpr$*)

Arguments:
strexpr$ a string expression.

Description:
The VAL function returns a REAL result that is the numeric conversion of the number at the beginning of *strexpr$*. If *strexpr$* can't be interpreted as a number, then VAL returns 0.

Note that this is much different than CVI or CVS, which convert a binary string into a number. Binary strings are not human readable, and in fact are just arrays of bytes.

Example:
```
100  INTEGER J: REAL X
110  STRING A$(60)
120  A$="123"
130  J=VAL(A$)
140  PRINT "Numeric value of "; A$; " is "; J
150  X=VAL("83.298")
160  PRINT "X = "; X
```

This produces the following output when run:

```
Numeric value of 123 is 123
X = 83.29799
```

Related topics:
STR$

VECTOR Statement

Summary:

The VECTOR statement stores the address of an interrupt service task at the specified address.

Syntax:

VECTOR *laddr*, *task*

Arguments:

laddr an integer expression. The address at which to store the address of the interrupt service task.

task an integer expression from 1 through 31. The task number of the interrupt service task.

Description:

VECTOR is used to link a hardware interrupt source to a Bear BASIC task. This is similar to the INTERRUPT statement, but INTERRUPT is much easier to use; in general, the only time that VECTOR will be used is when copying code supplied in a Divelbiss application note. When VECTOR is executed, the starting address of *task* is stored at *laddr*, which should be a hardware interrupt vector address. When the interrupt occurs, *task* will be executed as an interrupt service routine. Unlike INTERRUPT, VECTOR does not provide any hardware support for the interrupt source; specifically, it does not automatically clear the interrupt.

Example:

```
100  INTEGER X,T,RL,RLH,RLL,INTS
110  PRINT "Enter number of ints per second (5 to 2000): ";
120  FINPUT "U4",INTS
130  T = 0                          ' Initialize interrupt counter
140  FILE 6                         ' Write to the onboard display
150  GOSUB 200                      ' Set up timer interrupt
160  LOCATE 1,1: FPRINT "U5Z",T     ' Display current count
170  GOTO 160                       ' Loop forever
200  ' Set up timer 1 for specified interrupt rate
210  RL = 6144000.0 / 20.0 / INTS   ' Calc reload value
220  RLH = RL / $100                ' Calc high byte of reload
230  RLL = BAND (RL , $FF)          ' Calc low byte of reload
240  VECTOR $E6,1                   ' Set up timer vector to task 1
250  OUT $14, RLL : OUT $15, RLH    ' Init timer value
260  OUT $16, RLL : OUT $17, RLH    ' Init reload value
270  OUT $10, BOR(INP($10),$22)     ' Enable timer 1
280  RETURN
1000 ' Timer interrupt task
1010 TASK 1
1020 X=INP($10): X=INP($14)         ' Reset the timer 1 interrupt flag
1030 T=T + 1                        ' Increment counter value
1040 EXIT
```

This example demonstrates how to use the spare timer on the processor to generate an extremely accurate high speed timebase. Lines 110 and 120 get the timer rate from the user and store it in INTS. Line 130 calls the subroutine at line 200, which sets up the timer

interrupt. Line 210 calculates the reload value for the timer, which determines how many interrupts per second will be generated. Lines 220 and 230 split the reload value into a high byte and a low byte. Line 240 uses VECTOR to attach task 1 to the timer interrupt. Line 250 initializes the timer value, and line 260 initializes the reload value; every time the timer reaches 0, the reload value will be written into the timer. Line 270 starts the timer running. Lines 160 and 170 form the mainline of the program; they just print the current count value onto the onboard display. Task 1 is the timer interrupt task, at line 1000; every time the timer reaches 0, this task is executed. Line 1020 resets the timer 1 interrupt flag, which is necessary so that it doesn't jump back into task 1 as soon as it exits, since the interrupt flag would still be set. Line 1030 just increments a count value. Line 1040 EXITs back to continue processing; an interrupt task must end with an EXIT statement.

Related topics:

INTERRUPT, JVECTOR

WAIT Statement

Summary:

The WAIT statement delays execution of the current task for a specified period.

Syntax:

WAIT *num_tics*

Arguments:

num_tics a numeric expression from 1 to 32767. The number of tics (1/100 second) to delay. A tick equals 10msec which equals 1/100 second.

Description:

The WAIT statement provides an efficient way to put a delay into a program. It delays the execution of the current task for at least *num_tics* hundredths of a second; the task may be delayed for more than *num_tics*, depending upon how many tasks are ready to run when *num_tics* have elapsed. Any other tasks that are ready to run will continue to execute; if no other task is ready to run, then the processor will be idle until one of the tasks is done WAITing and can execute again. WAIT enables interrupts, since it depends upon the context switcher being called, so it can't be used inside of a hardware interrupt service task. WAIT works fine in a single-task program, the processor just sits idle until *num_tics* have elapsed.

Example:

```
100  RUN 1                          ' Start task 1 executing
110  PRINT "*";                     ' Print a '*' every 300 msec
120  WAIT 30: GOTO 110
130  TASK 1
140  PRINT "-";: GOTO 140           ' Print a '-' every 1 msec at 9600 baud
```

Related topics:

RUN, CANCEL, EXIT

WPEEK Function

Summary:
The WPEEK statement reads an integer word value from the specified address.

Syntax:
x = WPEEK (*logaddr*)

Arguments:
logaddr an integer expression. The logical address to read from.

Description:
The WPEEK function reads a word from memory at *logaddr*; it returns the word as an INTEGER. PEEK and WPEEK are similar, except that WPEEK reads a word (2 bytes), while PEEK only reads a byte. Normally, this reads from the 64KB address space that the BASIC program is running in. However, DEFMAP can be used to allow access to the entire 1MB physical address space; see DEFMAP for a complete explanation.

Example:
```
100  INTEGER J,K
110  WPOKE $A000,$1234              ' Write a $1234 into $A000
120  PRINT "$A000=";WPEEK($A000)
130  J=0: K=500
140  PRINT WPEEK(ADR(K))            ' Print the value of K
```

This produces the following output when run:

```
$A000=4660
500
```

Line 120 prints `$A000=4660` because 4660 is the decimal equivalent of $1234. Line 140 reads the variable K by WPEEKing the address of K.

Related topics:
WPOKE, POKE, PEEK, EEPOKE, EEPEEK, DEFMAP

WPOKE Statement

Summary:
The WPOKE statement writes an integer word value to the specified address.

Syntax:
WPOKE *logaddr*, *value*

Arguments:
logaddr an integer expression. The logical address to write to.
value an integer expression. The value to write.

Description:
The WPOKE statement writes a word (*value*) into memory at *logaddr*. POKE and WPOKE are similar, except that WPOKE writes a word (2 bytes), while POKE only writes a byte. Normally, this writes into the 64KB address space that the BASIC program is running in. However, DEFMAP can be used to allow access to the entire 1MB physical address space; see DEFMAP for a complete explanation.

Example:
```
100  INTEGER J,K
110  WPOKE $A000,$1234              ' Write a $1234 into $A000
120  PRINT "$A000=";WPEEK($A000)
130  J=0: K=500
140  WPOKE ADR(K),J                 ' Write a $0000 into low byte of K
150  PRINT K
```

This produces the following output when run:

```
$A000=4660
0
```

Line 120 prints `$A000=4660` because 4660 is the decimal equivalent of $1234. Line 140 stores a 0 into the variable K.

Related topics:
WPEEK, POKE, PEEK, EEPOKE, EEPEEK, DEFMAP

WRCNTR Statement

Summary:

The WRCNTR statement writes the count value into the high speed counter.

Syntax:

WRCNTR *chan*, *flag*, *expr*

Arguments:

chan an integer expression between 1 and the number of counter channels installed. This is the counter channel to write to.

flag an integer expression of 0 or 1. This determines whether to write to the actual counter or to the compare register:

- 0 to write to both the actual counter and the compare register.
- 1 to write to only the compare register.

expr a numeric expression. The count value to be stored. If it is an integer, then it will be sign-extended to fit into 24 bits. If it is a real, then all 24 bits will be stored.

Description:

The counter hardware has an actual count register and a compare register; WRCNTR is used to write a value to these registers. In order to write to the actual count, the value is also written into the compare register, which means that the actual count should always be set before the compare value is set.

The counter channels are assigned based on the hardware available on the Boss Bear; channel 1 could be the onboard counter, or in any of the expansion ports (if there is no onboard counter. The order of precedence for assigning counter channels is: onboard counter followed by J3 followed by J4 followed by J5.

Examples:

```
100  INTEGER COUNTI
120  CNTRMODE 1,4                    ' A count, B direction
130  WRCNTR 1,0,0                    ' Set count to 0
140  WRCNTR 1,1,10                   ' Set compare register to 10
150  ' Main program loop
160  RDCNTR 1,0,COUNTI               ' Read current count as integer
170  PRINT COUNTI
180  WAIT 10: GOTO 150
```

Related topics:

CNTRMODE, RDCNTR, Chapter 7

Chapter 9
Optional Modules

The Boss Bear will accept up to three expansion modules mounted onto **J3**, **J4**, and **J5** on the back of the unit. Any of the existing modules can be installed into any of the expansion connectors; at this time there are no modules that take advantage of the extra pins on **J3**. The expansion modules are powered by the Boss Bear, and do not require an external power supply.

The Boss Bear determines the channel numbers used for expansion modules based on the hardware that it finds. Channels are assigned starting with channel 1; channels are assigned in this order: onboard hardware, **J3**, **J4**, and **J5**. The following examples will clarify this:

- A Boss Bear has the onboard 10 bit A/D converter, a 3 channel DAC module in **J4**, and a 4 channel DAC module in **J5**. The onboard A/D will use A/D channels 1 through 12. The DAC module in **J4** will use DAC channels 1 through 3. The DAC module in **J5** will use DAC channels 4 through 7.

- A Boss Bear has the onboard 12 bit A/D converter, the onboard high speed counter, a differential A/D module in **J3**, a 2 channel high speed counter module in **J4**, and a single-ended A/D module in **J5**. The onboard A/D will use A/D channels 1 through 12. The A/D module in **J3** will use channels 13 through 20, since it is in differential mode (8 channels). The counter module in **J4** will use counter channels 2 and 3. The A/D module in **J5** will use A/D channels 21 through 36, since it is in single-ended mode (16 channels).

9.1 Module Installation

WARNING Do not install or remove any expansion module with power applied to the Boss Bear, as damage to the module and/or Boss Bear could result.

The Boss Bear expansion modules are secured to the Boss Bear with four 6-32 machine screws, each 1 5/8 inch long. A module can be installed in any Boss Bear expansion connector (**J3**, **J4**, or **J5**), although it allows easier access to the Boss Bear configuration jumpers and user EPROM if expansion modules are installed in **J4** and **J5** before **J3**. Note that it is simpler to configure the modules' jumpers before installing the modules on the Boss Bear.

Installing an expansion module in **J4** or **J5** is relatively easy, because these connectors are self-aligning with the module. Looking at the back of the Boss Bear with the lettering right side up, position the module over the desired connector, with the module's lettering right side up also. Press the module firmly into place, ensuring that the mating connectors have seated properly. Install the long screws into the corners of the module.

Expansion connector **J3** on the Boss Bear is intended for enhanced function modules and has more pins than **J4** and **J5**. Because of this, it is not self-aligning with some modules and requires more care when installing a module. Carefully position the expansion module over **J3** and align the left hand side of the module with the left hand side of the Boss Bear; press the module firmly into place. When the module is installed correctly, a counter-sunk machine screw will be visible on the Boss Bear to the right of the module; the module

partially covers the screw. If this screw is not visible, or the left hand side of the module is not flush with the left hand side of the Boss Bear, then the module is mis-mated and must be removed and re-installed properly. Install the long screws into the corners of the module.

Figure 20 and Figure 21 show the mounting dimensions of the Boss Bear expansion modules. These figures show the D/A module, but the overall dimensions of the other modules are the same.

9.2 High Speed Counter Module

The high speed counter module extends the Boss Bear beyond the single counter channel that can be installed onboard; by using three modules in addition to the onboard counter, the Boss Bear can support up to 13 counter channels. The counter module is available in four models:

Divelbiss Part Number	Description
EX-MOD-CTR24-01	1 channel counter module
EX-MOD-CTR24-02	2 channel counter module
EX-MOD-CTR24-03	3 channel counter module
EX-MOD-CTR24-04	4 channel counter module

Each channel is independent of the others, and each can accept a signal up to 100kHz without loss of counts on any channel; each channel is configured independently of the others. Each channel is very similar to the onboard counter on the Boss Bear, with **A**, **B**, **RESET**, and **LOAD** inputs and a high speed output. The **A**, **B**, and **RESET** inputs have individual low pass filters which the user can configure for 20Hz, 5kHz, or 100kHz. The **RESET** and **LOAD** inputs can be set individually by the user to accept active low or active high signals. The module is housed in an aluminum enclosure, with removable panels to allow user access to the configuration jumper blocks; it bolts to the Boss Bear with the mounting screws that are provided with the module.

Refer to chapter 7 for further information concerning programming and configuring the high speed counter module.

9.2.1 Wiring Recommendations

For best noise immunity, shielded cable should be used between the counter inputs and the device being monitored; this is especially important for long cable runs. To minimize any potential crosstalk problems between channels, it is recommended that individually paired and shielded cables be used for each channel, especially at high counting speeds. Use the shield terminal provided or connect the shield to earth ground by other means. Do not connect the cable shield at both ends of the cable, as this can have an adverse effect. Always use separate returns (minus terminal) for each channel, as this lessens the chance of ground loops occurring by making all common terminations at the counter module.

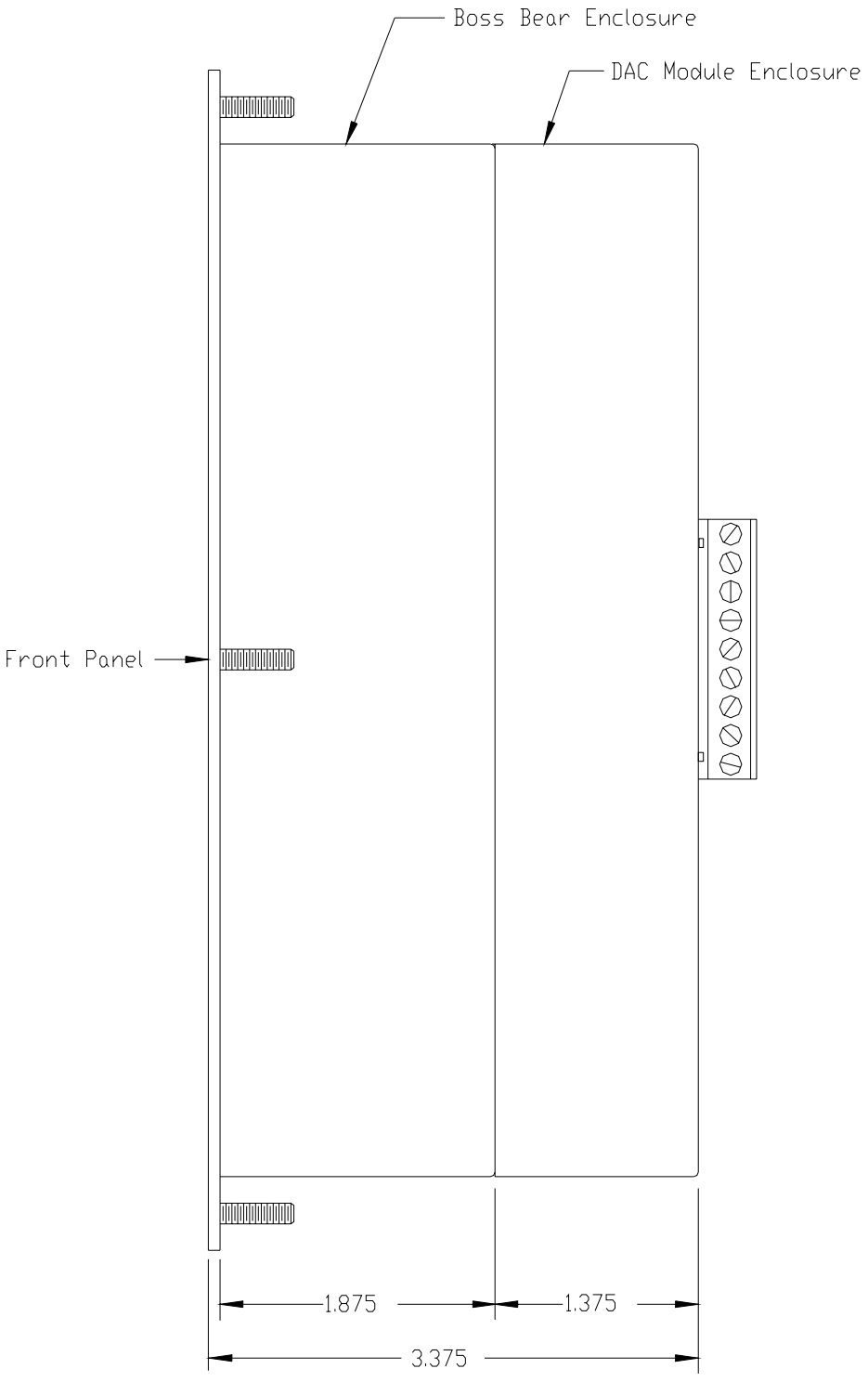


Figure 20 – Expansion Module Side View

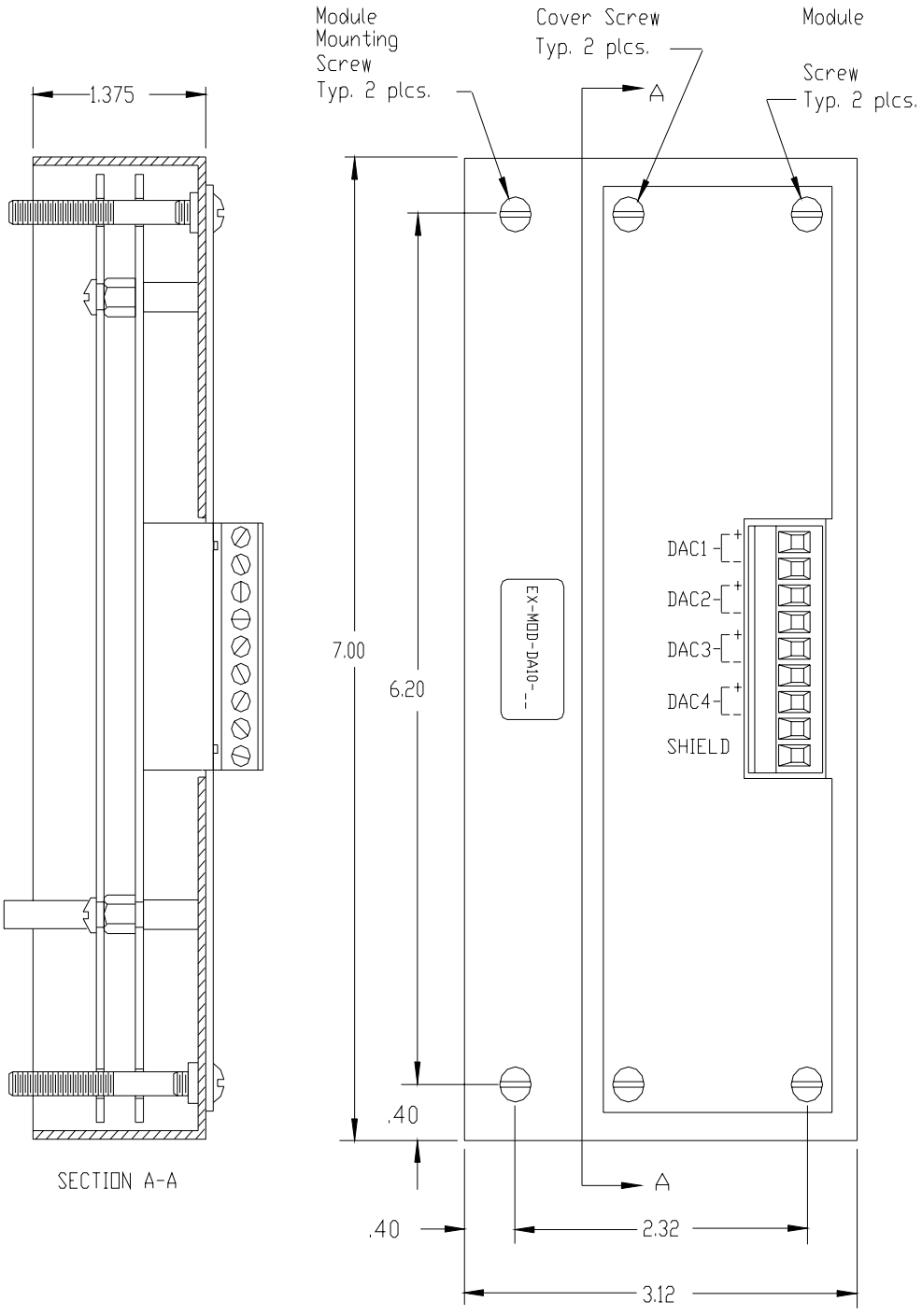


Figure 21 – Expansion Module Panel View

9.2.2 Counter Module Terminal Block Description

+VA Unregulated +10 to +15VDC. This can be used for excitation of external transducers. This is supplied to the terminal block of all channels.

+AX Counter input A for this channel.

GND Input/Output return. This is electrically connected to the Boss Bear digital common. It is not internally connected to earth ground, and should not be connected externally to earth ground.

+BX Counter input B for this channel.

+RX Counter reset input for this channel.

+LX Counter load input for this channel.

GND Input/Output return. This is electrically connected to the Boss Bear digital common. It is not internally connected to earth ground, and should not be connected externally to earth ground.

+CX Counter high speed output for this channel.

SHD Cable shield termination. This is used for the drain wire termination of cables coming to this counter channel. This is electrically connected to the Boss Bear earth ground system, which includes all of the metal on the Boss Bear enclosure. This depends upon the Boss Bear power connector being wired correctly to earth ground.

9.2.3 Counter Module Jumper Configuration

Refer to Figure 22 to set the jumpers for the counter module.

9.2.4 Specifications

Channels:	1, 2, 3, or 4, depending upon part number
Resolution:	24 bits
Inputs:	Each channel has 4 inputs: **A**, **B**, **RESET**, and **LOAD**. All inputs are self-sourcing and can be driven with open collector (open drain) drivers. The open circuit potential is 10-15VDC.
Input current:	Logic low: 3.2mA maximum Logic high: 1□A at 15VDC maximum
Input low level:	1VDC maximum
Input high level:	3.5VDC minimum
Max. high level input (sourcing):	+12VDC
Input filtering:	Individually user selectable for inputs **A**, **B**, and **RESET** on each channel: 20Hz (±20%), 5kHz (±20%), 100kHz (±20%).

High Speed Output drive:	Open drain (open collector). Maximum sink current: 100 mA continuous.
Available power:	**+VA** is available for each channel: 10 to 15VDC, unregulated. Maximum collective load current: 80mA.
Wiring termination:	Detachable terminal blocks on 5mm centers. Maximum wire size: #18AWG.

9.2.5 User Replaceable Parts List

The following components are available from Divelbiss for user replacement, if necessary:

Divelbiss Part Number	Description
116-101673	9 position removable terminal block
117-100849	Output mode programming shunts
120-101705	Mounting screws
120-100636	Cover screws

9.3 12 Bit Analog to Digital Converter Module

The 12 bit A/D converter module provides enhanced analog measurement capabilities to the Boss Bear. It can be configured with 16 single-ended channels, 8 differential channels, or 8 current loop (4-20mA) channels. The input span can be set to 0 to +5V, 0 to +10V, -5 to +5, -10 to +10V, or 4 to 20mA; because the channels are multiplexed, all channels are set to the same mode. The 4 to 20mA mode is factory configured and cannot be changed by the user. The A/D module is accessed using the ADC() function of Bear BASIC. The A/D module is available in three models:

Divelbiss Part Number	Description
EX-MOD-AD12-S	16 single-ended inputs, field selectable as 0 to +5V, 0 to +10V, -5 to +5, or -10 to +10V.
EX-MOD-AD12-D	8 differential inputs, field selectable as 0 to +5V, 0 to +10V, -5 to +5, or -10 to +10V.
EX-MOD-AD12-C	8 current loop (4 to 20mA) inputs. This features a "true" current loop, in that it is not referenced to any common. This analog input mode provides the best immunity to noise and cable loss.

9.3.1 Wiring Recommendations

For best noise immunity, shielded cable should be used between the analog inputs and the device being monitored; this is especially important for long cable runs. Except in cases where the analog signals are very dynamic, all channels can be sheathed in the same cable, with one common overall shield. Use the shield terminal provided or connect the shield to earth ground by other means. Do not connect the cable shield at both ends of the cable, as this can have an adverse effect. Always use separate returns (minus terminal) for each channel, as this lessens the chance of ground loops occurring by making all common terminations at the A/D module; of course, separate returns are required when using the differential and 4-20mA modules.

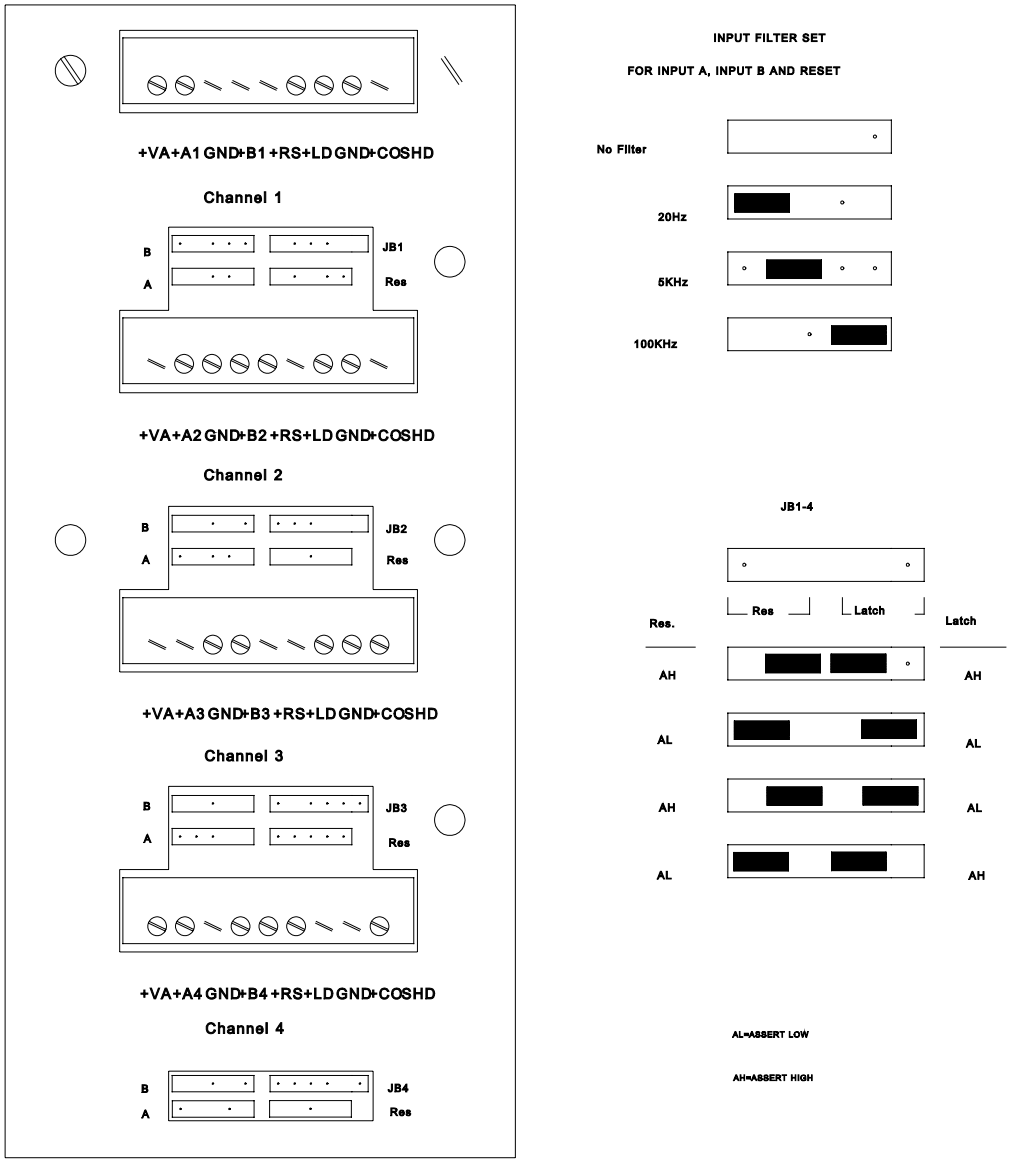


Figure 22 – Counter Module Jumper Configuration

9.3.2 12 bit A/D Module Jumper Configuration

Refer to **Figure 23** and **Figure 24** to set the A/D module jumpers.

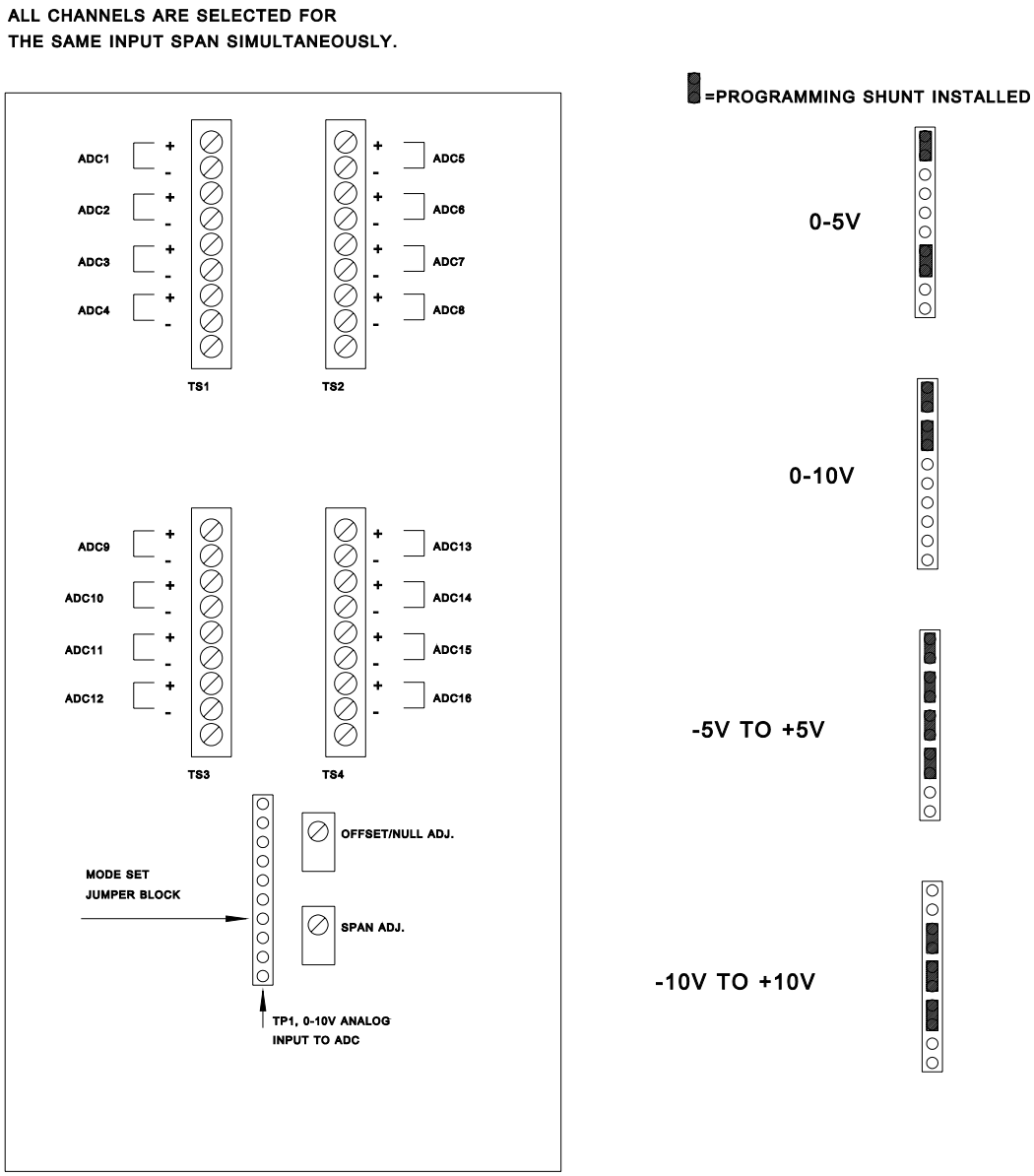


Figure 23 – A/D Module Jumper Configuration, Single Ended

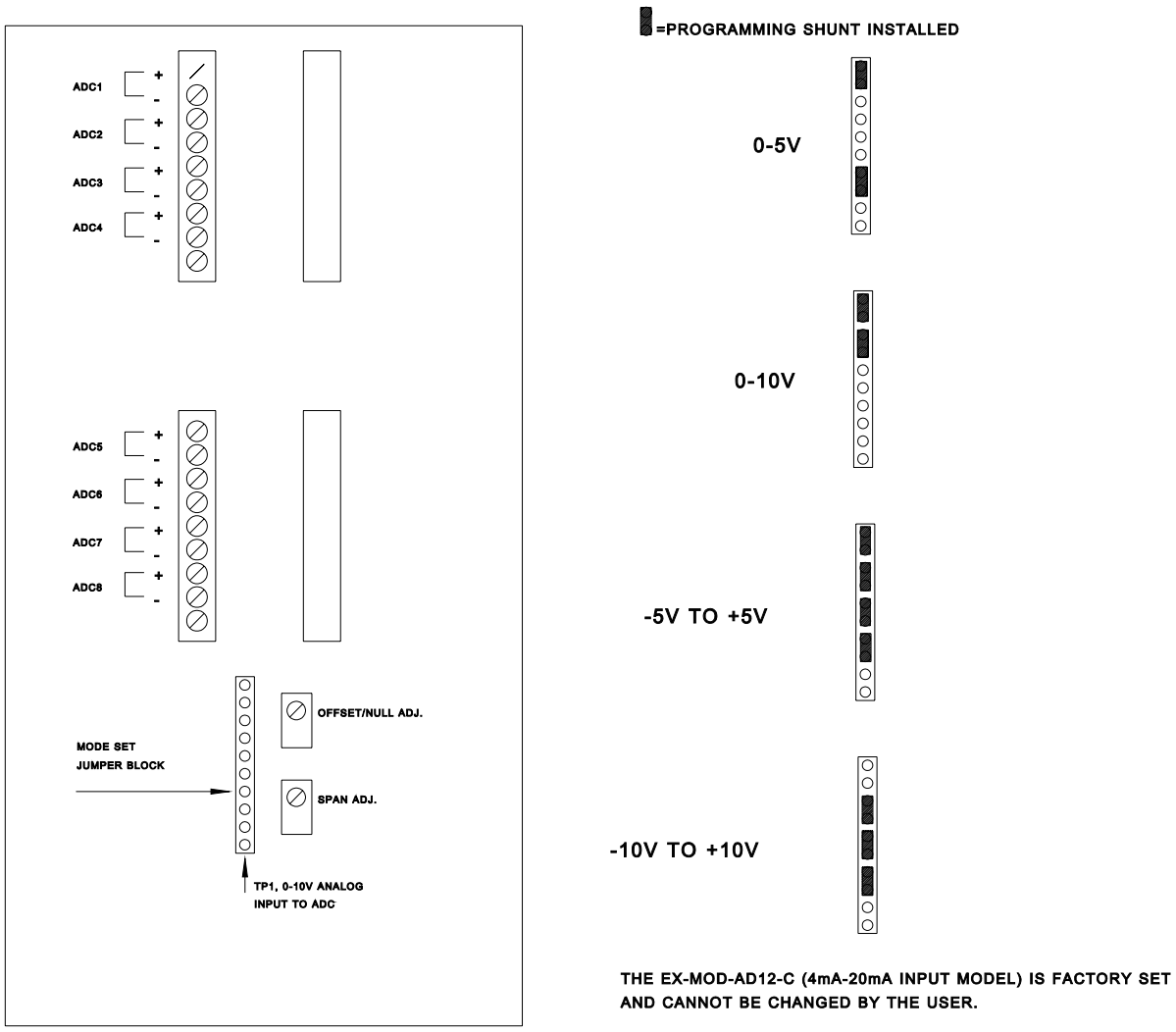


Figure 24 – A/D Module Jumper Configuration, Differential and 4-20mA

9.3.3 12 bit A/D Module Calibration

The EX-MOD-AD12-S and EX-MOD-AD12-D modules are shipped from the factory set and calibrated for the -5 to +5V single-ended input range. If an input span other than this is selected, then the module must be calibrated. The EX-MOD-AD12-C module is, of course, shipped set and calibrated for 4 to 20mA. Any of the modules can be calibrated at any time, if the user feels that it is necessary.

Before beginning the calibration, allow at least a five minute warm-up period with the power applied to the Boss Bear and modules. This allows the OP-AMP buffers to reach operating temperature and stabilize. A very clean and stable DC power source is required for accurate calibration; a laboratory power supply or mercury battery are suitable. A multimeter that is accurate to 0.5mV (with a 10VDC input) is also required.

The following Bear BASIC program is used to display the A/D readings during calibration; it should be entered and running:

```
100  ' Program to calibrate 12 bit A/D expander module
     integer mode, chanl
     real anlgrd, zero, span
     integer j,ch
     string a$

     data "0 to 5V", "0 to 10V", "-5 to 5V", "-10 to 10V", "4 to 20mA"
     data 0.0, 5.0, 0.0, 10.0, -5.0, 10.0, -10.0, 20.0, 4.0, 16.0

     file 6

300  ' Get operating mode (0-5, 0-10, etc.) from the user
     erase
     print " 1:0 to 5V    2:0 to 10V    3:-5 to 5V"
     print "4:-10 to 10V  5:4 to 20mA     Press 1-5";
320  ch = get
     if ch < $31 or ch > $35 then 320
     mode = ch - $30

     ' Get channel number to calibrate
     erase
     print "Enter channel number to calibrate>";
     finput "u2",chanl

     ' Display range that was chosen (ie. "-5 to 5V")
     erase
     restore
     for j = 1 to 5
       read a$
       if j = mode then print a$;
     next j
     locate 1,15
     print "Channel ";chanl;
     locate 2,10
     print "Press a key to exit";

     ' Get the zero and span values for the chosen mode
     for j = 1 to mode
       read zero,span
     next j

     ' Main loop to read the A/D and display the value.  Exit this loop when
     ' a key is pressed.
400  anlgrd = adc(chanl)/32767.0 * span + zero
     locate 1,26
     fprint "f3.3z",anlgrd
     if mode < 5 then print "V";
     if mode = 5 then print "mA";
     wait 20                          ' Delay to allow user to read number
     if key=0 then 400
     goto 300
```

Calibrating the unipolar input modes (0 to 5V, 0 to 10V):

With the BASIC A/D calibration program running, short the plus and minus inputs of channel 1 with a jumper wire. Adjust the NULL adjustment until 0.000V is displayed by the program. Remove the shorting jumper and apply 1/2 of the input span voltage level to the channel 1 input terminals, observing polarity; this is 2.500V for the 0-5V mode, 5.000V for the 0-10V mode. Adjust the span pot until the displayed value matches the input level. The calibration can be verified by applying 5.000V or 10.000V (depending on the mode selected) to the channel 1 input terminals; the displayed value should match the input voltage level.

Calibrating the bipolar input modes (-5 to +5V, -10 to +10V):

With the BASIC A/D calibration program running, short the plus and minus inputs of channel 1 with a jumper wire. Adjust the NULL adjustment until 0.000V is displayed by the program. Remove the shorting jumper and apply +5.000V or +10.000V (depending upon the mode selected) to the channel 1 input terminals, observing polarity. Adjust the span pot until the displayed value matches the input level. The calibration can be verified by applying -5.000V or -10.000V (depending on the mode selected) to the channel 1 input terminals; the displayed value should match the input voltage level.

Calibrating the current loop (4 to 20mA) input mode:

With the BASIC A/D calibration program running, apply 4.00mA to channel 1 and adjust the null pot until 4.00 is displayed. Apply 20.00mA to channel 1 and adjust the span pot until 20.00 is displayed.

9.3.4 Specifications

Channels:	8 or 16, depending upon part number
Resolution:	12 bits
Input level:	For models EX-MOD-AD12-S and EX-MOD-AD12-D, user selectable: 0 to +5V, 0 to +10V, -5 to +5, -10 to +10V. For model EX-MOD-AD12-C, factory set: 4 to 20mA.
Input linearity error:	±1 least significant bit.
Input noise rejection:	±1 least significant bit.
Input impedance:	Model / Impedance / Channel tracking EX-MOD-AD12-S / 2.3MΩ min. / N/A EX-MOD-AD12-D / 3.3MΩ min. / N/A EX-MOD-AD12-C / 250Ω, ±2% / ±0.2%,0-60□C
Maximum input voltage:	For models EX-MOD-AD12-S and EX-MOD-AD12-D, the maximum safe input voltage on any channel is 24VDC.
Input termination:	Detachable terminal blocks on 5mm centers. Maximum wire size: #18AWG. Two terminals are provided for

	each channel, with a shield terminal for each group of four channels.
Conversion time:	600□sec, using the ADC() function of Bear BASIC.

9.3.5 User Replaceable Parts List

The following components are available from Divelbiss for user replacement, if necessary:

Divelbiss Part Number	Description
116-101673	9 position removable terminal block
117-100849	Output mode programming shunts
120-101705	Mounting screws
120-100636	Cover screws

9.4 10 Bit Digital to Analog Converter Module

The 10 bit D/A converter module provides analog output capabilities to the Boss Bear. Using this module, up to 12 analog outputs can be added to a Boss Bear. Each channel can be individually set to 0 to +5V, 0 to +10V, -5 to +5, -10 to +10V, or 4 to 20mA. The D/A module is available in four models:

Divelbiss Part Number	Description
EX-MOD-DA10-01	1 channel DAC module
EX-MOD-DA10-02	2 channel DAC module
EX-MOD-DA10-03	3 channel DAC module
EX-MOD-DA10-04	4 channel DAC module

In the 4 to 20mA mode, this unit implements a "true" current loop; it is not referenced to any common. This is the best D/A drive to use for optimum immunity to noise and cable loss. The output current is regulated and can maintain the chosen analog output over a wide range of load impedance.

9.4.1 Wiring Recommendations

For best noise immunity, shielded cable should be used between the analog outputs and the device being controlled; this is especially important for long cable runs. Except in cases where the analog signals are very dynamic, all channels can be sheathed in the same cable, with one common overall shield. Use the shield terminal provided or connect the shield to earth ground by other means. Do not connect the cable shield at both ends of the cable, as this can have an adverse effect. Always use separate returns (minus terminal) for each channel, as this lessens the chance of ground loops occurring by making all common terminations at the D/A module. #22AWG or larger wire can be used for runs of less than 15 feet; for longer runs #18AWG is recommended for minimum signal loss due to wire resistance. For very long cable runs, the 4-20mA mode is recommended, since it compensates for cable loss (within design limitations).

9.4.2 10 bit D/A Module Jumper Configuration

The output drive level can be individually set for each output channel. Each channel has two 9 pin jumper blocks that control the mode. Refer to **Figure 25** to set the D/A module jumpers.

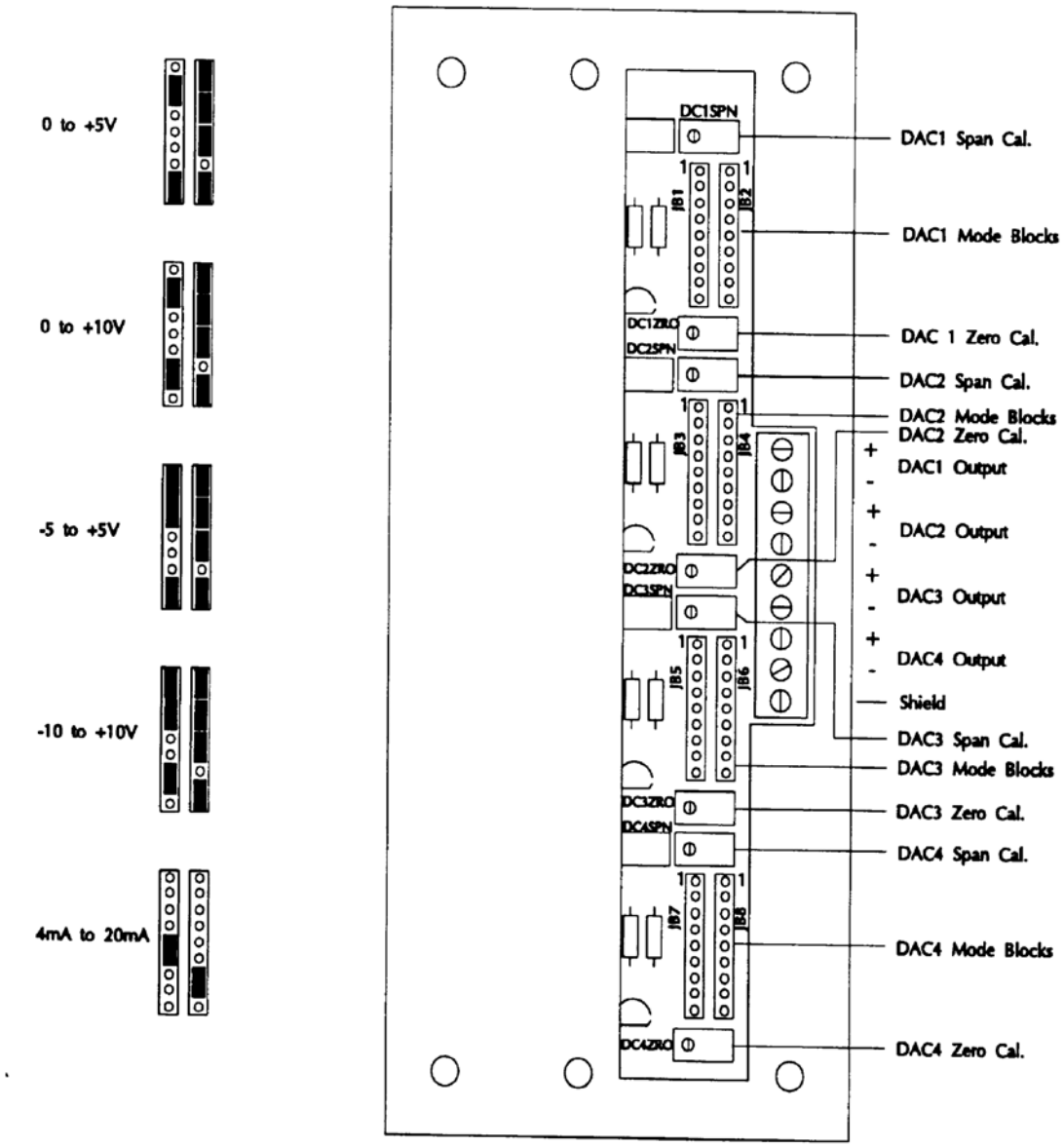


Figure 25 – D/A Module Jumper Configuration

9.4.3 10 bit D/A Module Calibration

All channels are factory set and calibrated for the -10 to +10V mode. If an output mode other than -10 to +10V is selected, the calibration will be necessary. The operating mode should be set before connecting the module to any machine or interface device, in order to avoid any confusion and possible damage. Often, it is not necessary to calibrate the module to an absolute standard, because the channels will need to be adjusted in conjunction with other equipment (for example, adjusting the zero potentiometer to cause a motor to stop all motion).

Before beginning the calibration, allow at least a five minute warm-up period with the power applied to the Boss Bear and modules. This allows the OP-AMP buffers to reach operating temperature and stabilize. A multimeter that is accurate to 0.005V (with a 10V input) is required.

The following Bear BASIC program is used to set the analog outputs during calibration; it should be entered and running:

```
100  ' Program to calibrate 10 bit D/A expander module
     integer mode, chanl
     real anlgset, zero, span
     integer j,ch
     string a$

     data "0 to 5V", "0 to 10V", "-5 to 5V", "-10 to 10V", "4 to 20mA"
     data 0.0, 5.0, 0.0, 10.0, -5.0, 10.0, -10.0, 20.0, 4.0, 16.0

     file 6

300  ' Get operating mode (0-5, 0-10, etc.) from the user
     erase
     print " 1:0 to 5V    2:0 to 10V    3:-5 to 5V"
     print "4:-10 to 10V  5:4 to 20mA     Press 1-5";
320  ch = get
     if ch < $31 or ch > $35 then 320
     mode = ch - $30

     ' Get channel number to calibrate
     erase
     print "Enter channel number to calibrate>";
     finput "u2",chanl

     ' Display range that was chosen (ie. "-5 to 5V")
     erase
     restore
     for j = 1 to 5
       read a$
       if j = mode then print a$;
     next j
     locate 1,15
     print "Channel ";chanl;

     ' Get the zero and span values for the chosen mode
     for j = 1 to mode
       read zero,span
     next j

     ' Main loop to get the desired output level from the user and set the
     ' D/A to this value.
```

```
400  locate 2,1
     print "Enter output level >                  ";
     locate 2,29
     if mode < 5 then print "V";
     if mode = 5 then print "mA";
     locate 2,22
     finput "f3.3",anlgset
     if anlgset < zero or anlgset > (zero+span) then 400
     dac chanl, (anlgset - zero) / span * 1023
     locate 2,1
     print "F1-next level    Any other key to exit";
     ch = get
     if ch = $41 then 400
     goto 300
```

Calibrating the unipolar input modes (0 to 5V, 0 to 10V):

With the BASIC D/A calibration program running, select the desired channel to calibrate, and specify 0 as the DAC output value. Adjust the proper zero potentiometer for 0.00V on the output terminals of the channel being calibrated. Next, specify 2.5 or 5.0 (depending upon the range) as the DAC output value. Adjust the proper span potentiometer for the midpoint of the voltage range selected (2.499V for the 0-5V range, or 4.99V for the 0-10V range). The calibration can be verified by specifying 5.0 or 10.0 as the DAC output value; the output should measure 4.99 to 5.00V, or 9.99 to 10.00V, depending upon the mode.

Calibrating the bipolar input modes (-5 to +5V, -10 to +10V):

With the BASIC D/A calibration program running, select the desired channel to calibrate, and specify 0 as the DAC output value. Adjust the proper zero potentiometer for 0.00V on the output terminals of the channel being calibrated. Next, specify 5.0 or 10.0 as the DAC output value. Adjust the proper span potentiometer for the maximum value of the voltage range selected (4.99V for the ±5V range, or 9.99V for the ±10V range). The calibration can be verified by specifying -5.0 or -10.0 as the DAC output value; the output should measure -4.99 to -5.00V, or -9.99 to -10.00V, depending upon the mode.

Calibrating the current loop (4 to 20mA) input mode:

Use a 250Ω (5% or better) load across the channel being calibrated; refer to **Figure 26**. With the BASIC D/A calibration program running, select the desired channel to calibrate, and specify 4.0 as the DAC output value. Adjust the proper zero potentiometer for 4.00mA through the test load. Next, specify 20.0 as the DAC output value. Adjust the proper span potentiometer for a 20.0mA reading. The calibration can be verified by specifying 12.0 as the DAC output value; the multimeter should read 12.0mA.

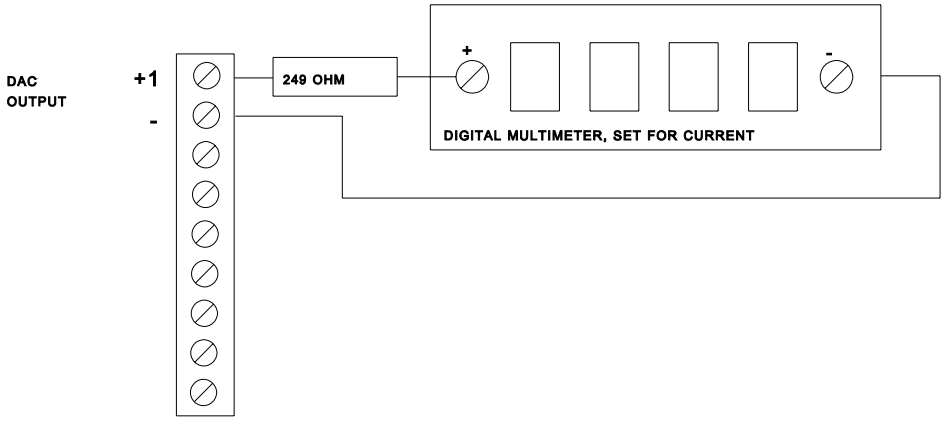


Figure 26 – D/A Module 4-20mA Calibration Setup

9.4.4 Specifications

Channels:	1, 2, 3, or 4, depending upon part number
Resolution:	10 bits
Output level:	Each channel is user selectable: 0 to +5V, 0 to +10V, -5 to +5, -10 to +10V, or 4 to 20mA.
Output null/offset adjustments:	±250mV, or 0-6mA in current (4 to 20mA) mode.
Output linearity error:	±0.05% FSR maximum.
Output noise:	Less than 4mV peak to peak.
Output drive current:	For voltage output modes: 10mA minimum at 10V.
Compliance voltage:	For current (4 to 20mA) mode: 9VDC minimum.
Load tolerance:	For current (4 to 20mA) mode: 250□, ±20%.
Output termination:	Detachable terminal blocks on 5mm centers. Maximum wire size: #18AWG. Two terminals are provided for each channel, with a single shield terminal.

9.4.5 User Replaceable Parts List

The following components are available from Divelbiss for user replacement, if necessary:

Divelbiss Part Number	Description
116-101673	9 position removable terminal block
117-100849	Output mode programming shunts
120-101705	Mounting screws
120-100636	Cover screws
BM-8910579-3	Cover

Chapter 10
Networking with the Boss Bear

In a modern industrial control system, it is often necessary to transfer data between widely spaced elements of the system. Examples of this include: bringing production information from multiple locations to a central processing point, sending machine configuration from a central control point, and using multiple control elements to form a distributed control system. The elements in such a system may be a few feet apart, or they may be thousands of feet apart. The communications system to perform these operations is commonly called a Local Area Network.

The Boss Bear supports the Bear Direct network, which is a master/slave, RS-485 multidrop network that has been designed to be inexpensive and reliable in the industrial environment. Up to 32 devices can be connected together using two conductor twisted pair wiring; up to 250 devices can be connected using repeaters. The total network cabling length can be up to 1000 feet.

10.1 Bear Direct Networking Principles

A computer network is a set of hardware and software that allows two or more computers to transfer data; the term isn't usually applied to simple serial connections between two computers. There are many different types of networks, using many different communication methods; each type has features that make it better suited to certain applications. In general, as the network size and speed increase, the complexity (and cost) increase as well. In keeping with the low cost design philosophy of the Boss Bear, the Bear Direct network operates at a low speed, doesn't require expensive hardware to be added to the Boss Bear, and uses simple twisted pair wiring.

The function of the network hardware and software is to transfer data between remote points without errors. Since the communications media always has a relatively high error rate (compared with most other computer hardware), the network must be designed to detect these errors and get the correct data through. The Bear Direct network uses a 16 bit CRC (Cyclic Redundency Code) checksum and sequence bits to detect transmission errors. If an error is detected the data is transferred again until it is received correctly; after several attempts, the transfer is aborted. The error checking and retransmission is handled by the Boss Bear network driver software, transparently to the BASIC programmer.

The Bear Direct network uses a multidrop, master/slave topology. The term "multidrop" means that all devices are connected to a single pair of wires; in other words, each unit is not only attached to its neighbor, but also to every other unit. This implies that while one unit is transmitting, all other units must be in receive mode; if two units try to transmit concurrently then both data transfers will be corrupted. A master/slave network is used to ensure that only one unit will transmit at a time. The term "master/slave" is used because the network is managed by one unit (the "master"), which controls the communications of the other units (the "slaves"). Currently, the master must be the Bear Direct Network Interface card, which installs into an ISA bus personal computer. If the master is not operating, then none of the slaves will be able to communicate.

The network handler on a Boss Bear must be initialized before that Boss Bear can communicate on the network. This is done at the beginning of a Bear BASIC program with

the NETWORK 0 statement. This sets the unit's network address and allocates space for the network registers. Each unit on the network must have a unique address, between 0 and 254, inclusive. The network registers are stored in an area of RAM that BASIC normally doesn't access; this area is split between the integer, real, and string registers, and can be up to about 20000 bytes.

There are two different methods of transferring data over the network: network registers and messages. The two methods can both be used in a program at the same time. When communicating between Boss Bears, either method may be used. When communicating with a personal computer, network registers support the Lotus @Factory$_{TM}$ interface, while messages support the BearLog data logging TSR program.

10.1.1 Network Registers

The Boss Bear supports the network using a set of network registers. These registers can be accessed by both the BASIC program and the network driver software, independently of each other. In Bear BASIC, the registers are written to with the NETWORK 3 statement; they are read with the NETWORK 4 statement. There are three types of network registers: integer, real, and string. A network register is NOT automatically transferred across the network when the BASIC program writes to that register; the register must be explicitly sent by the unit using the NETWORK 1 statement, read by another unit using the NETWORK 2 statement, or read by the network master. The network registers can be thought of as an intermediate storage area between BASIC and the actual network handler; they relieve the programmer from the having to worry about handling network messages at the moment that they come in.

The network register method is well suited to situations where one unit needs to monitor the current state of another unit. For example, suppose that a PC is used to display the current production totals for the machines on the network. Each Boss Bear will update its network registers as items are produced; the PC will read this data every few seconds and display it. Notice that there is no need in this example for the Boss Bear to send a specific piece of data (ie. production data for a particular part) to the PC; this is more difficult using network registers, because a register must be used as a flag to indicate that this specific data is available. The example below demonstrates this operation.

The NETWORK 3 and NETWORK 4 statements write into and read out of network registers, respectively. This happens independently of network accesses to the network registers, so that the BASIC program could be writing data into a network register while the network master is reading data out of a network register. Each individual register access is protected, however, so that a register won't be read halfway through a write cycle; in other words, once data is being written into a register, that register won't be read until the data is entirely written.

The NETWORK 1 and NETWORK 2 statements transfer network registers from one Boss Bear to another; this is referred to as peer to peer communications. The transfer is actually performed via the network master; as more units are added to a network, the transfer time will increase, because it will take longer for the master to poll through the network.

10.1.2 Network Messages

The Boss Bear often needs to send a group of data to another unit on the network. For example, after each part is produced, the dimensions and weight for this part must be sent to a personal computer, so that the information can be stored in a file for later SPC (Statistical Process Control) analysis. The easiest way to handle this is for the Boss Bear to send a message, containing all of the pertinent data, to the destination PC. This transfers all of the associated data at one time, eliminating the possibility that only part of the data will get transferred. This also minimizes network activity, since the PC doesn't have to continuously poll the Boss Bear to see if new part has been produced. This is the only way to transfer data to the Divelbiss BearLog data logging TSR program.

The Bear BASIC function NETMSG() sends and receives network messages. A message is treated as a string in the BASIC code; data is stored in the string using the normal string functions: CONCAT$(), STR$(), MKI$(), CVI$(), ASC(), VAL(), CHR$(), etc. After the data is stored in the string, it is sent with the instruction ST=NETMSG(0,UNIT,MSG$), where UNIT is the unit to send the message to, MSG$ is the message to send, and ST is the result code. This will wait for the network master to poll, respond with the message, and wait for the acknowledgement from the master before returning. If this process doesn't complete within approximately 5 seconds, then NETMSG returns an error.

The instruction ST=NETMSG(1,UNIT,MSG$) retrieves a message that has been received. UNIT will be set to the number of the unit that sent the message, MSG$ is the message, and ST is the result code. If no message is available, then NETMSG will return 0 and MSG$ and UNIT will be unchanged. If a message has been received, then NETMSG will return 1 and MSG$ and UNIT will be set appropriately. The Boss Bear network handler can buffer a few incoming messages while it is waiting for the BASIC code to retrieve them; the number that can be buffered depends upon the number of network registers allocated, but is always at least 2.

It is possible to broadcast a message to all units on the network simultaneously. This is done by sending a message to unit number $FF; every unit will receive this message at the same time. This is used when the activities of multiple Boss Bears must be synchronized. For example, a message could be sent at the end of each shift to cause all units to add up the shift totals and send them back.

In most network applications, there are several types of data that are transferred around. There must be a flag in each message that identifies what type of data the message contains. This is called the message type, and is held in the first byte of a message (the first character in the string). When sending data to the BearLog TSR, the message type tells which file to store the data from this message into; in this case, the message type is between 0 and the number of files being created on the personal computer. The message types between 192 and 255 are reserved for system messages (defined by Divelbiss), such as the time update message (number 255). When sending messages between Boss Bears, the message types can be any number less than 192 and greater than the number of files being created by the BearLog program.

10.2 Bear BASIC Network Examples

The following examples demonstrate the use of the Bear Direct network from within a Bear BASIC program; these examples are referred to throughout this chapter. The examples show the main network operations that are useful in a production monitoring system: uploading current production values, uploading values when data is available at the Boss Bear (product totals in the example), and uploading values when the central (master) computer needs them (shift totals in the example). The first example (referred to as NETDEMO1.BAS) will be used in this chapter with a Lotus 123$_{TM}$ spreadsheet (section 10.4). The second example (referred to as NETDEMO2.BAS) will be used with the BearLog data logging TSR (section 10.5).

10.2.1 Network Register Example

This program demonstrates how to transfer data using only the network registers. A problem occurs when a block of data must be transferred: a flag register must be used to indicate that the entire block of data is valid. This is necessary so that one unit doesn't read part of the block while the other unit is updating the block, which would cause incorrect information to be transferred.

In this program, the PC must continually read integer register 0 (I0), to see if new product data is available. If I0 is 1, then the PC must read I1 through I4 (which contain the totals for the product), and then set I0 back to 0. At the end of the shift, the PC must write a 1 to I10, to tell the Boss Bear that the shift totals are needed. The Boss Bear checks I10 periodically; when it sees I10 set to 1, it will put the current shift totals into registers I12 through I16, and then set I11 to indicate to the PC that the shift totals have been stored. The PC will then read I12 through I16 and store the data.

```
100   ' NETDEMO1.BAS - Demo program for Boss Bear network.
      '
      ' This program demonstrates how to program the Boss Bear
      ' for network applications.  It simulates a simple data
      ' collection system, including a user interface using the
      ' onboard display and keypad.  It counts items moving
      ' through 4 different sensors, corresponding to small,
      ' medium, large, and defective.  The operator sorts the
      ' production items and puts each item onto a conveyor
      ' which will take it past one of the sensors.  The
      ' operator periodically enters a product number, which
      ' will be assigned to the product items that follow.
      '
      ' The system will maintain the total count for each sensor
      ' for the current product.  When a new product number is
      ' entered, these totals will be put into network registers
      ' for transfer to the central computer.  The system also
      ' maintains total counts for the current shift.  At the
      ' end of the shift, these totals will be transferred to the
      ' central computer, as well.
      '
      ' Network register usage:
      ' I0      flag to indicate new product data available
      ' I1-I4   product counts for entire product run
      ' I5      product number
      ' I6-I9   current product counts
      ' I10     flag from Central indicating end of shift
```

```
      ' I11     flag to indicate new shift data available
      ' I12-I15 shift totals
      ' I16     operator number at shift end
      '
      ' NOTE:
      '   The unit address is stored in EEPROM at location 1.  This
      '   must be set up by another program, since this program
      '   only reads that location.
      '
      '************************************************************
      ' Variable declarations
      integer J, K
      integer PRDNUM                ' Product number
      integer OPNUM                 ' Operator number
      integer PRD(3)                ' Product totals
      integer SHIFT(3)              ' Shift totals
      integer SIMDELY               ' Delay variable for simulation


      ' Variables used by user-interface subroutines
      integer UIVLU, UIFLAG
      real UIRVLU
      string UIFMT$(50), UIFMT2$(50)


500   '************************************************************
      ' Program initialization
      for J = 0 to 3
        PRD(J) = 0                  ' Reset the count totals
        SHIFT(J) = 0
      next J

      SIMDELY = 0                   ' Init simulation delay to 0

      file 6
      network 0,eepeek(1),20,0,0,K  ' Initialize the network handler
      if K then print "Network initialization error";: stop
      network 3,0,10,0,K            ' Clear Central 'shift end' flag
      network 3,0,11,0,K            ' Clear 'new shift data' flag
      network 3,0,0,0,K             ' Clear 'new product data' flag
      for J = 0 to 3
        network 3,0,6+J,0,K         ' Reset current count in network reg
      next J

      gosub 5000                    ' Get product num and operator num

1000  '************************************************************
      ' Program mainline.
1010  gosub 8800                    ' Print monitor screen
      K = key
      if K=$41 then gosub 5000
      gosub 2000                    ' Check the photo-eye sensors
      gosub 2500                    ' Handle the network
      wait 1
      goto 1010

2000  '************************************************************
      ' Check the state of the photo eye sensors.  If any of them
      ' have turned on, then update the corresponding count variable.

      ' Since this is a simulation, we will use random numbers to
      ' pick which photo eye has turned on.  First, though, we have
      ' a random time delay between photo eye turn-ons.
      if SIMDELY <> 0 then SIMDELY = SIMDELY - 1: goto 2499

      SIMDELY = rnd / 4000 + 16     ' Random delay of about 1 second
      J=rnd / 32768.0 * 1.7 + 1.7   ' Simulate photo eye turning on

      ' J contains the number of the input that has turned on, so
```

```
      ' update the product count and shift count for that input.
      PRD(J) = PRD(J) + 1
      network 3,0,6+J,PRD(J),K      ' Update current count in network reg
      SHIFT(J) = SHIFT(J) + 1
2499  return

2500  '************************************************************
      ' Check for end of shift message from Central.  It will set
      ' register 10 to 1 when the end of shift occurs.  This is our
      ' signal to copy the shift totals into network registers,
      ' after which we set register 11 to 1 to signal Central that
      ' there is new data waiting.
      network 4,0,10,J,K
      if J = 0 then 2999            ' If flag not set then return

      for J = 0 to 3
        network 3,0,12+J,SHIFT(J),K ' Store shift totals in network reg's
        SHIFT(J) = 0                ' Reset shift totals
      next J
      network 3,0,16,OPNUM,K        ' Store current operator number
      network 3,0,11,1,K            ' Set flag to indicate new data
      network 3,0,10,0,K            ' Clear flag so we don't do this again

2999  return

5000  '************************************************************
      ' Subroutine to handle user keypad input.

      UIFMT$ = "Product number (0-9999) > ": UIVLU = PRDNUM
      gosub 8300
      ' A new product number has been entered.  Store the current
      ' count values into network registers; set the 'new product'
      ' flag register, which will signal Central that there is new
      ' data available.
      for J = 0 to 3
        network 3,0,J+1,PRD(J),K    ' Store product count totals
      next J
      network 3,0,5,PRDNUM,K        ' Store product number with counts
      network 3,0,0,1,K             ' Set flag to indicate new data

      ' Now reset the product counts and update the product number.
      for J = 0 to 3
        PRD(J) = 0                  ' Reset the count totals
        network 3,0,6+J,PRD(J),K    ' Reset current count in network reg
      next J
      PRDNUM=UIVLU                  ' Set up new product number

5100  UIFMT$ = "Operator number (0-9999) > ": UIVLU = OPNUM
      gosub 8300: if UIFLAG then OPNUM=UIVLU

      for J=1 to 10: K=key: next J  ' Empty keyboard buffer
      return

8300  '************************************************************
      ' Subroutine to get INTEGER user input.
      cls: print UIFMT$; UIVLU;: wait 30
8310  K = din ($100): if K=0 then 8310
      if K = $41 or K = 13 then K=key: UIFLAG=0: return
      if K<$30 or K>$39 then K=key: goto 8310
      locate 1,len(UIFMT$)+1: print "       ";
      locate 1,len(UIFMT$)+1: finput "I4", UIVLU
      UIFLAG=1: return

8800  '************************************************************
      ' Subroutine to print monitor screen
      locate 1,1
      print "Small     Medium    Large     Defective"
      fprint "i5x5i5x5i5x5i5x5z", PRD(0), PRD(1), PRD(2), PRD(3)
      return
```

10.2.2 Network Message Example

This program is similar to the previous one, except that it uses network messages to transfer the product and shift totals to the PC. The current production counts are still stored in network registers, so that a Lotus 123™ spreadsheet can be used to display the current information. The product totals are sent using message type 1, with the product number being used to form the filename on the PC. The incoming time updates (from the PC) are used to determine when the end of the shift occurs, and then the shift end data is sent using message type 0.

```
100   ' NETDEMO2.BAS - Demo program for Boss Bear network.
      '
      ' This program demonstrates how to program the Boss Bear
      ' for network applications.  It simulates a simple data
      ' collection system, including a user interface using the
      ' onboard display and keypad.  It counts items moving
      ' through 4 different sensors, corresponding to small,
      ' medium, large, and defective.  The operator sorts the
      ' production items and puts each item onto a conveyor
      ' which will take it past one of the sensors.  The
      ' operator periodically enters a product number, which
      ' will be assigned to the product items that follow.
      '
      ' The system will maintain the total count for each sensor
      ' for the current product.  When a new product number is
      ' entered, these totals will be put into a network message
      ' for transfer to the central computer.  The system also
      ' maintains total counts for the current shift.  At the
      ' end of the shift, these totals will be transferred to the
      ' central computer.
      '
      ' Network register usage:
      ' I6-I9   current product counts, read periodically by PC
      '
      ' Network message types used:
      ' 0       shift end totals, sent at 7am, 3pm, and 11pm
      ' 1       product totals, sent when a new product number is entered
      ' $FF     incoming time update from network master
      '
      ' NOTE:
      '   The unit address is stored in EEPROM at location 1.  This
      '   must be set up by another program, since this program
      '   only reads that location.


      '*************************************************************
      ' Variable declarations
      integer J, K, N, M
      integer PRDNUM                ' Product number
      integer OPNUM                 ' Operator number
      integer PRD(3)                ' Product totals
      integer SHIFT(3)              ' Shift totals
      integer SIMDELY               ' Delay variable for simulation
      integer DAYMIN                ' Time of day in minutes (0 to 1439)
      string MSG$(127)              ' Network message

      string LJZF8ST$
      integer INTGER


      ' Variables used by user-interface subroutines
      integer UIVLU, UIFLAG
```

```
      real UIRVLU
      string UIFMT$(50), UIFMT2$(50)


500   '************************************************************
      ' Program initialization
      for J = 0 to 3
        PRD(J) = 0                  ' Reset the count totals
        SHIFT(J) = 0
      next J

      DAYMIN = -1                   ' Time of day not valid yet.
      SIMDELY = 0                   ' Init simulation delay to 0

      file 6
      network 0,eepeek(1),20,0,0,K  ' Initialize the network handler
      if K then print "Network initialization error";: stop
      for J = 0 to 3
        network 3,0,6+J,0,K         ' Reset current count in network reg
      next J

      gosub 5000                    ' Get product num and operator num

1000  '************************************************************
      ' Program mainline.
1010  gosub 8800                    ' Print monitor screen
      K = key
      if K=$41 then gosub 5000
      gosub 2000                    ' Check the photo-eye sensors
      gosub 2500                    ' Handle the network
      wait 1
      goto 1010

2000  '************************************************************
      ' Check the state of the photo eye sensors.  If any of them
      ' have turned on, then update the corresponding count variable.

      ' Since this is a simulation, we will use random numbers to
      ' pick which photo eye has turned on.  First, though, we have
      ' a random time delay between photo eye turn-ons.
      if SIMDELY <> 0 then SIMDELY = SIMDELY - 1: goto 2499

      SIMDELY = rnd / 4000 + 16     ' Random delay of about 1 second
      J=rnd / 32768.0 * 1.7 + 1.7   ' Simulate photo eye turning on

      ' J contains the number of the input that has turned on, so
      ' update the product count and shift count for that input.
      PRD(J) = PRD(J) + 1
      network 3,0,6+J,PRD(J),K      ' Update current count in network reg
      SHIFT(J) = SHIFT(J) + 1
2499  return

2500  '************************************************************
      ' Check for end of shift message from Central.
      K = netmsg(MSG$,1,J)          ' Check for time update message
      if K = 0 then 2999            ' Return if no message
      if len(MSG$) < 7 then 2999    ' Return if too short
      if mid$(MSG$,1,1) <> chr$($FF) then 2999

      ' Calculate the time of day in minutes, then check for shift
      ' change (7am, 3pm, 11pm).
      DAYMIN = asc(mid$(MSG$,5,1))*60 + asc(mid$(MSG$,6,1))
      if DAYMIN = 420 then 2600     ' Jump if 7am
      if DAYMIN = 900 then 2600     ' Jump if 3pm
      if DAYMIN <> 1380 then 2999   ' Jump if not 11pm

2600  MSG$ = chr$(0)                ' Message type 0
      for J = 0 to 3
        ' Store shift totals in message string, then reset shift totals
```

```
        MSG$ = CONCAT$(MSG$,MKI$(SHIFT(J)))
        SHIFT(J) = 0
      next J
      MSG$=CONCAT$(MSG$,MKI$(OPNUM))      ' Store current operator number

      K = netmsg(MSG$,0,0)          ' Send the message to the PC
      if K <> 0 then cls:print "Network error":stop

2999  return

5000  '************************************************************
      ' Subroutine to handle user keypad input.

      UIFMT$ = "Product number (0-9999) > ": UIVLU = PRDNUM
      gosub 8300
      ' A new product number has been entered.  Store the current
      ' count values into a network message, then send the message
      ' to the PC.
      MSG$ = chr$(1)                ' Message type 1
      INTGER = PRDNUM: gosub 9000   ' Convert product number to filename
      MSG$ = CONCAT$(MSG$,LJZF8ST$) ' Store filename in message
      for J = 0 to 3
        MSG$ = CONCAT$(MSG$,MKI$(PRD(J))) ' Store product count totals
      next J

      K = netmsg(MSG$,0,0)          ' Send the message to the PC
      if K <> 0 then cls:print "Network error":stop

      ' Now reset the product counts and update the product number.
      for J = 0 to 3
        PRD(J) = 0                  ' Reset the count totals
        network 3,0,6+J,PRD(J),K    ' Reset current count in network reg
      next J
      PRDNUM=UIVLU                  ' Set up new product number

5100  UIFMT$ = "Operator number (0-9999) > ": UIVLU = OPNUM
      gosub 8300: if UIFLAG then OPNUM=UIVLU

      for J=1 to 10: K=key: next J  ' Empty keyboard buffer
      return

8300  '************************************************************
      ' Subroutine to get INTEGER user input.
      cls: print UIFMT$; UIVLU;: wait 30
8310  K = din ($100): if K=0 then 8310
      if K = $41 or K = 13 then K=key: UIFLAG=0: return
      if K<$30 or K>$39 then K=key: goto 8310
      locate 1,len(UIFMT$)+1: print "       ";
      locate 1,len(UIFMT$)+1: finput "I4", UIVLU
      UIFLAG=1: return

8800  '************************************************************
      ' Subroutine to print monitor screen
      locate 1,1
      print "Small     Medium    Large     Defective"
      fprint "i5x5i5x5i5x5i5x5z", PRD(0), PRD(1), PRD(2), PRD(3)
      return

9000  '************************************************************
      ' Subroutine to convert an integer to a left justified, zero
      ' filled, 8 character string.  For example, 123 becomes "00123   ",
      ' and 34567 becomes "34567   ".
      ' Input: INTGER is the number to convert
      ' Output: LJZF8ST is the string
      ' Modifies: J, K, M
      M = 10000: LJZF8ST$ = ""
      for J = 1 to 5
        K = INTGER / M
        LJZF8ST$ = concat$(LJZF8ST$,chr$(K+$30))
```

```
  INTGER = INTGER - K * M
  M = M / 10
next J
LJZF8ST$ = concat$(LJZF8ST$,"   ")
return
```

10.3 Using the Network Interface Card

The Bear Direct Network Interface card is actually a full microcomputer system that is programmed to act as the Bear Direct master unit, or as another network slave, allowing multiple PCs on the Bear Direct network. It accepts commands from the personal computer's processor and performs the requested operation. It installs in an ISA bus personal computer; it can be installed in either an 8 bit or 16 bit card slot. The network cable is plugged into the card's bottom 9 pin D connector.

The program BDSETUP.EXE must be run on the personal computer to operate the Network Interface card. It accepts command line parameters, so it can be used with batch files for automatic system configuration. It is used to initialize the Network Interface card, set network operation parameters, and display the network status. Multiple commands can be entered on the same command line; the commands are executed in left to right order. It accepts the following commands:

BDSETUP -U This displays a brief description of the program usage.

BDSETUP -? Same as -U option.

BDSETUP -A *address* This sets the address where BDSETUP.EXE will find the card. If the card address has been changed from its default value (300H), then this must be the first thing on the command line. For example, to initialize the card when it is at address 340H, type **BDSETUP -A 340 -L 0**.

BDSETUP -L *unitnum* This initializes the card and sets the network address of the card to *unitnum*. This must be done before the card can be used, and before any of the following commands are performed. This sets the number of units in the network to 1, and turns network polling off.

BDSETUP -N *numunits* This sets the number of units in the network. For example, in a network with 3 Boss Bears (and the Network Interface card), the command **BDSETUP -N 3** would be used.

BDSETUP -P ON or **OFF** This turns the network polling on or off; it should only be used if the card is the network master (unit 0). Polling should only be turned on if the Boss Bear programs are executing NETWORK 1 or NETWORK 2 statements (peer to peer communications), or the NETMSG function (messages are being sent). For example, to turn network polling on, the command **BDSETUP -P ON** would be used.

BDSETUP -R *numretry* This sets the retry count for the card; it is only valid if the card is the network master (unit 0). The master normally retries an unsuccessful communications attempt 5 times before aborting the attempt. The number of retries can be set from 1 to 20 with this command.

BDSETUP -T ON or **OFF** This turns the network time update on or off. When it is turned on, the card will broadcast the current time and date every minute.

BDSETUP -E [***unit***] This displays the number of units in the network, the polling state (on or off), and the retry count for 64 units (starting at *unit*, or 1 if *unit* isn't specified).

In most Bear Direct networks, a network interface card will be the network master, which is the heart of the network. In order to get the best network operation, it is important that the card is configured correctly. The following examples show some common configurations.

The network includes 10 Boss Bears (the slaves) and the Network Interface card (the master). Lotus @FACTORY is being used with the DIRECT.EXE TSR program. No network messages are being used in the system, and no peer to peer communications are taking place. Time updates are not needed. The command line to configure the card would be BDSETUP -L 0 -N 10

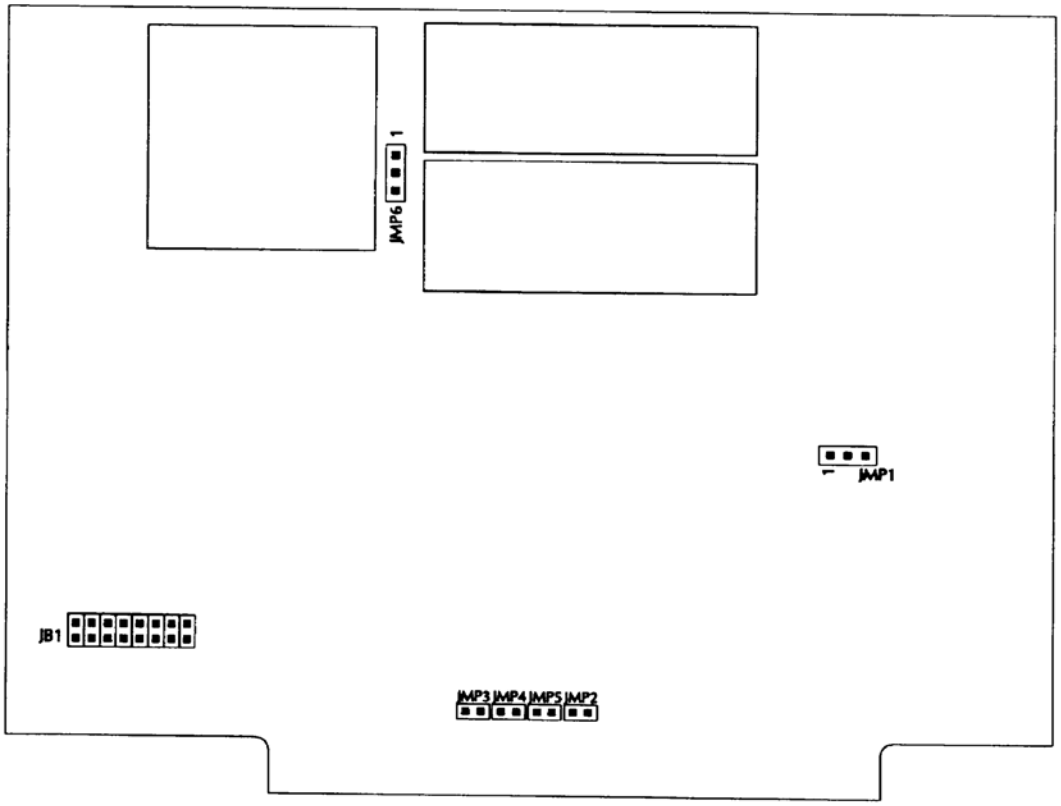
The network includes 5 Boss Bears (slaves, numbered as units 1 through 5), a Network Interface card located in the plant PC (the master), and a Network Interface card located in an office PC (a slave, unit number 6). The plant PC is running @FACTORY to display real time production data. The office PC is running the BearLog TSR to log long-term production data; this means that network polling must be enabled. Time updates must be sent, to ensure that all units have the correct time. The plant PC would use BDSETUP -L 0 -N 6 -P ON -T ON to configure the card. The office PC has the card located at address 360H; it would use BDSETUP -A 360 -L 6 to configure the card.

10.3.1 Network Time Update

When the time update function of the Network Interface Card is enabled, it will broadcast a "time update" message to all units once each minute. The "time update" message is 7 bytes long, and has the message type $FF followed by 6 bytes (year, month, day, hour, minute, second). If the current PC time is 11:23:00 on March 28, 1992, then the message would be:

<$FF><92><3><28><11><23><0>

It is up to the BASIC programmer to retrieve the "time update" message and process it appropriately. In some cases the programmer may want to use the incoming time to update the real time clock. Refer to the NETDEMO2.BAS example (above) to see how the time update is used in a BASIC program.



The card address is set using JB1. It can be set to any multiple of 4 between 000H and 3FCH, by installing jumpers in the bit locations that must be 0. These examples show some common address choices:

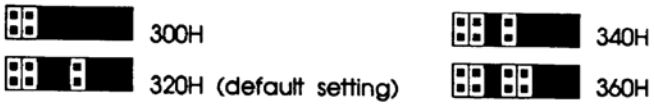


Figure 27 - Network Interface card address jumpers

10.3.2 Getting a Test Network Running

The following instructions show how to get a minimal network (one Boss Bear) up and running.

1. Install the Network Interface card into any slot in the PC. The card is shipped with the address jumpers set to 320H. If this I/O address is already in use by another card, then set the Network Interface card to an unused address (refer to Figure 27 to set the address jumpers). If the card address is changed from the default value, then the -A option must be used each time that BDSETUP is run.

2. The network cable plugs into the bottom 9 pin D connector on the card. It plugs into the COM2 connector on the Boss Bear.
3. Make sure that the Boss Bear COM2 port is set to RS-485 mode. This is set by jumper **JW1** inside of the Boss Bear. (See Section 7)

4. Enter the following program into the Boss Bear:

```
100  integer ST
200  network 0,1,100,100,10,ST
210  if ST then print "Error": stop
300  goto 300
```

This program just initializes the network handler to address 1, 100 integer registers, 100 real registers, and 10 string registers.

5. At the DOS prompt, type the `BDSETUP -L 0` command to initialize the software on the Network Interface card to unit 0 (the network master). If the card address has been changed from the default value, the -A option must precede the -L option; for example, if the card is at address 380H, type `BDSETUP -A 380 -L 0` to initialize the card.

6. Type `BDSETUP -N 1` to set the number of units on the network to 1. Actually, this is the default value set up by the -L command above. If the card address has been changed from the default value, the -A option must precede the -N option; for example, if the card is at address 380H, type `BDSETUP -A 380 -N 1` to initialize the card.

7. Type `BDSETUP -P ON` to enable network polling. Again, remember to use the -A option if the card address has been changed from the default value.

8. Type `BDSETUP -E` (with the -A option, if necessary) to print the status screen. This will produce something similar to the following:

```
Bear Direct setup program  v1.01
Divelbiss Corp.  1991,1992

Software version 1.02     Unit number 0
Network size set to 1 unit.  Polling is on.
Operating for 12634 seconds
XXX         0         0         0         0         0         0         0
  0         0         0         0         0         0         0         0
  0         0         0         0         0         0         0         0
  0         0         0         0         0         0         0         0
  0         0         0         0         0         0         0         0
  0         0         0         0         0         0         0         0
  0         0         0         0         0         0         0         0
  0         0         0         0         0         0         0         0
```

The XXX indicates where the error count for unit number 1 will be displayed. If everything is working correctly, it should be 0 at this point.

9. Type `BDSETUP -P OFF` (with the -A option, if necessary) to disable network polling. Polling is only necessary in a system where Boss Bears need to communicate peer to peer.

10. Type `NETTEST 1` to perform a short network test. This will send a packet with 20 integers to the Boss Bear, then read it back to verify that it was successfully received. It does this with 25 different data sets. It also sends a packet with real numbers and verifies it. If everything is working, it will print the numbers 0 to 24 and then a series of real numbers.

Notes:

A. `BDSETUP -U` will show a small help screen.

B. `NETTEST 1 40 1000` will perform 1000 test transfers, using packets that contain 40 integers each, with unit 1. The middle argument (40, above) should be between 1 and 70. The last argument must be less than 32768.

C. If the network polling is enabled, NETTEST will slow down because of the extra overhead imposed by the polling operation.

10.4 Interfacing to Lotus 123

The Bear Direct network can be accessed with the popular spreadsheet Lotus 123$_{TM}$, by using the Lotus add-in @FACTORY$_{TM}$ in conjunction with the Divelbiss driver program DIRECT.EXE. @FACTORY adds two new functions to Lotus 123: @READ and @WRITE. These functions read and write register data in Boss Bear network registers over the network.

10.4.1 Loading DIRECT.EXE

Before @FACTORY can be used from within Lotus 123, the DIRECT.EXE driver must be loaded. To start DIRECT.EXE, at the DOS prompt type `direct -a`*addr* where *addr* is the card address. When shipped from the factory, the card is set to default address 320H, so you would normally type `direct -a320H` to load the driver. The -a switch tells the TSR where the card is addressed. If this switch is not given then the program will simply terminate without going memory resident; the -a switch must be given.

The only other switch to be used with DIRECT.EXE is -u. Once DIRECT.EXE is resident it can be unloaded from memory by specifying the "-u" switch, by typing `direct -u` at the DOS command line. This should unload the TSR from memory. If there was another TSR loaded after DIRECT.EXE, then it may not be possible to unload DIRECT.EXE from memory.

10.4.2 Using Lotus @FACTORY

The operation of @FACTORY is described fully in the documentation that is supplied with it, but a brief introduction is given here to cover the features that are specific to the Divelbiss Bear Direct network. @FACTORY is an add-in to Lotus 123, which means that it loads into 123 and adds new functions to it. Install the @FACTORY files as shown in the @FACTORY documentation. After starting 123, select "/ Add-In Attach", which will show a menu of add-ins that are available; select @FACTFUN and press ENTER, then select "Quit" to exit the Add-In menu. The functions @READ and @WRITE are now available for use.

The @READ function reads a register value from a Boss Bear; the syntax of @READ is:
@READ(*unit,regnum,vartype*)

unit the unit number of the Boss Bear to access. This is a string containing a number between "1" and "254".

regnum the register number to read. This is a string containing a number.
vartype the variable data type to be read from the device: "unsigned16" for an integer register, "float" for a float register, or "string" for a string register.

Each @READ argument can be a string enclosed in quotes, a cell address, a range address, or an @function that returns a string value. The following examples show the proper use of @READ:

`@READ("3","10","float")` This reads float register 10 from unit 3.

`@READ(B5,B6,"unsigned16")` This uses values from other spreadsheet cells. If B5 is "4", and B6 is "7", then this would read integer register 7 from unit 4.

The @WRITE function writes a register value to a Boss Bear; the syntax of @WRITE is: @WRITE(*value,unit,regnum,vartype*)

value the data to be written to the device. This can be a cell, range, or range name.
unit the unit number of the Boss Bear to access. This is a string containing a number between "1" and "254".
regnum the register number to write to. This is a string containing a number.
vartype the variable data type to be written to the device: "unsigned16" for an integer register, "float" for a float register, or "string" for a string register.

Each @WRITE argument can be a string enclosed in quotes, a cell address, a range address, or an @function that returns a string value. The following examples show the proper use of @WRITE:

`@WRITE(27.45,"3",@string(10),"float")` This writes the value 27.45 into float register 10 of unit 3.

`@WRITE(B4,B5,B6,"unsigned16")` This uses values from other spreadsheet cells. If B4 is 999, B5 is "4", and B6 is "7", then this would write 999 to integer register 7 of unit 4.

10.5 BearLog Data Logging TSR Program

The Bear Direct network can be used to log data onto a personal computer disk drive using the TSR program BEARLOG.EXE, which is a TSR (Terminate and Stay Resident) program. The BearLog program can be configured to store information in dBase IV$_{TM}$ compatible files, or in user specified format files. It runs in the background, checking several times per second for incoming messages; when a message arrives, it appends the data to the end of the correct file. It can log data into multiple files; each message specifies the file type that it should go into.

10.5.1 BearLog Configuration File

The BearLog program is controlled by a configuration file (BEARLOG.CFG). This file specifies which data files will be created and how they will be updated. The data can be stored in a single file, or a new data file can be created each hour, each shift, each day, or each week. The data files are stored in separate subdirectories based on file type. An example will make this structure clearer. Assume that a system generates three data file types: hourly production data, shift downtime totals, and weekly SPC data. The BearLog

program is loaded in the directory C:\BEARLOG; the data will be stored in three subdirectories of C:\BEARLOG: C:\BEARLOG\PRODHOUR, C:\BEARLOG\DOWNTIME, and C:\BEARLOG\SPC_WEEK. The following files would be written on the hard disk drive between March 1, 1992 at 7:00 AM and March 18, 1992 at 4:00 PM:

Subdirectory	Filename	Start time for data in file
PRODHOUR	92030207.DAT	March 2, 1992, 7:00 AM
	92030208.DAT	March 2, 1992, 8:00 AM
	92030209.DAT	March 2, 1992, 9:00 AM
	.	.
	.	.
	92030216.DAT	March 2, 1992, 4:00 PM
	.	.
	.	.
	92031817.DAT	March 18, 1992, 5:00 PM
DOWNTIME	92030207.DBF	March 2, 1992, shift 1
	92030215.DBF	March 2, 1992, shift 2
	92030223.DBF	March 2, 1992, shift 3
	92030307.DBF	March 3, 1992, shift 1
	.	.
	.	.
	92031815.DBF	March 18, 1992, shift 2
SPC_WEEK	92030100.DAT	Week of March 1, 1992
	92030800.DAT	Week of March 8, 1992
	92031500.DAT	Week of March 15, 1992

The configuration file to set up this structure would look like this:

```
SHIFT=7                    Shift 1 starts at 7:00 AM
SHIFT=15                   Shift 2 starts at 3:00 PM
SHIFT=23                   Shift 3 starts at 11:00 PM
WEEK=0                     Week starts on Sunday
FILE=PRODHOUR.DAT,1        File type 0, hourly, raw data file
FILE=DOWNTIME.DBF,2        File type 1, shift, dBase file
FILE=SPC_WEEK.DAT,4        File type 2, weekly, raw data file
```

The comments on the right are for descriptive purposes only; they are not part of the file.

Upon starting BEARLOG.COM the file BEARLOG.CFG must exist and have files to use as templates. BEARLOG.CFG is the default configuration filename. The -f switch can be used to specify a different filename. The configuration file is only read when BEARLOG.COM is first executed. The format for the configuration file is as follows:

Each line starts with a keyword; lines that are not started with a keyword are ignored, which allows comments to be put into the configuration file. The keywords are:

SHIFT=*sh_hour* *sh_hour* is the hour number (0-23) that a shift begins on.

FILE=*string*,*class* *string* is a valid DOS filename with extension. The extension determines what format the data is logged into the files. "DBF" would be DBASE IV format and "DAT" would be staight data.

class is a number which determines when a new file is opened to log data into.

0 - Continuous file; all data will go into one file.
1 - Open a new file every hour.
2 - Open a new file according to the shift times.
3 - Open a new file every day.
4 - Open a new file every week.
5 - Each data packet will specify the filename to store its data in.

WEEK=*wday* *wday* is a number 0-6 which tells which day to start the week on (ie. when to open the weekly files). 0 is Sunday, 1 is Monday, etc.

To use the NETDEMO2.BAS program (above), the configuration file would look like this:

```
WEEK=1
FILE=SHIFT.DBF,4
FILE=PROD.DBF,5
```

This would store the shift data (message type 0) into the subdirectory SHIFT as dBase files, with a new file each week. The week starts on Monday. The product totals would be stored in the subdirectory PROD as dBase files, with the filenames being supplied by the Boss Bear.

Note that when using file type 5, in which the Boss Bear supplies the filename as the first eight characters of the message, that the filename is not stored in the file. For example, the message `<01>FILE1 DATA` would store the string "DATA" into file FILE1.DAT, assuming that message type 1 was raw data file.

10.5.2 BearLog Data File Formats

Two file formats are supported: dBase IV and raw data. A raw data file is signified by a file extension of ".DAT". The message string is stored into the file with no data conversion. This allows the Boss Bear programmer to determine the format of the data file. The first byte of the message, which is the file type flag, is not stored in the file. If three numbers need to be stored with comma delimiters in an ASCII text file, for example, the BASIC program could build the message string like this: `MSG$=CONCAT$(CHR$(2), CONCAT$(STR$(NUM1), CONCAT$(",", CONCAT$(STR$(NUM2), CONCAT$(",", STR$(NUM3) )))))`. Notice that the file type (the first byte of the message) is 2, which would cause this message to be appended to the current file in the SPC_WEEK subdirectory.

A dBase IV compatible file is signified by a file extension of ".DBF". Before the first message arrives, there must be a dBase .DBF file stored in the subdirectory for the BearLog program to use as a template. The message string is converted into the format of this dBase template file. For example, a template file is created from within dBase that has three fields per record: an integer number, a floating point number, and a 10 character string. This template file is stored in the DOWNTIME subdirectory (file type 1). The BASIC code to build the message string would look like `MSG$=CONCAT$(CHR$(1), CONCAT$(MKI$(DNUM), CONCAT$(MKS$(DVLU), NAME$)))`. The first byte is set to 1, which is

the file type. The value of DNUM is stored in the next two bytes. The value of DVLU is stored in the next 4 bytes. The string NAME$ is stored in the next 10 bytes; the program must ensure that NAME$ is exactly 10 bytes long before storing it in MSG$.

For each file entry there must be a corresponding subdirectory of the same name (minus the extension). When creating dBase files, each dBase subdirectory must contain a template file. The template file is simply a small database that defines the record types being used; only the record type is used, any data in the file is disregarded by BEARLOG.COM. For raw data files a template file is not needed.

10.5.3 Sharing Data Files

The BearLog TSR executes each PC timer tick (18.2 times per second); it retrieves a packet, if one is waiting, and tries to store the data into the appropriate disk file. If the data cannot be stored to disk right now (if the disk system is already busy, for example), then it will attempt to store the data on the next timer tick. If it can't be stored within about 5 seconds, then the packet is discarded and the next packet is read.

It is possible for a program running on the PC to try to open a file that the BearLog TSR is accessing; this could happen if a database program were analyzing data as the data was collected. Two condititions must be met in order for this to work correctly: SHARE must be loaded in the PC, and the program must only open the file for a short period of time. SHARE.EXE is a program that is supplied with DOS, that prohibits one program from accessing a file that another program is accessing. As long as the foreground program (ie. the database program) only opens the data file for less than one or two seconds, no data will be lost. The network version of most PC programs will fulfill this requirement.

10.5.2 BearLog Data File Formats

Since this is a low speed, RS-485 network, the cabling requirements are very modest. An unshielded twisted pair, with a separate common lead, is daisy-chained from one unit to the next. The total cable length should not exceed 1000 feet. A 150 ohm, 1/2 watt resistor must be placed across the signal lines at the furthest end of the cable from the personal computer.

Divelbiss has sold two different Network Interface Cards, each with different pinouts on the connectors. The first one was a 3/4 length ISA bus card; Figure 28 shows the wiring diagram for this version of the Network Interface Card. The newer card uses pinouts that match the Boss Bear **COM2** connector; it is a 1/2 length ISA bus card. Figure 29 shows the wiring diagram for the newer Network Interface Card.

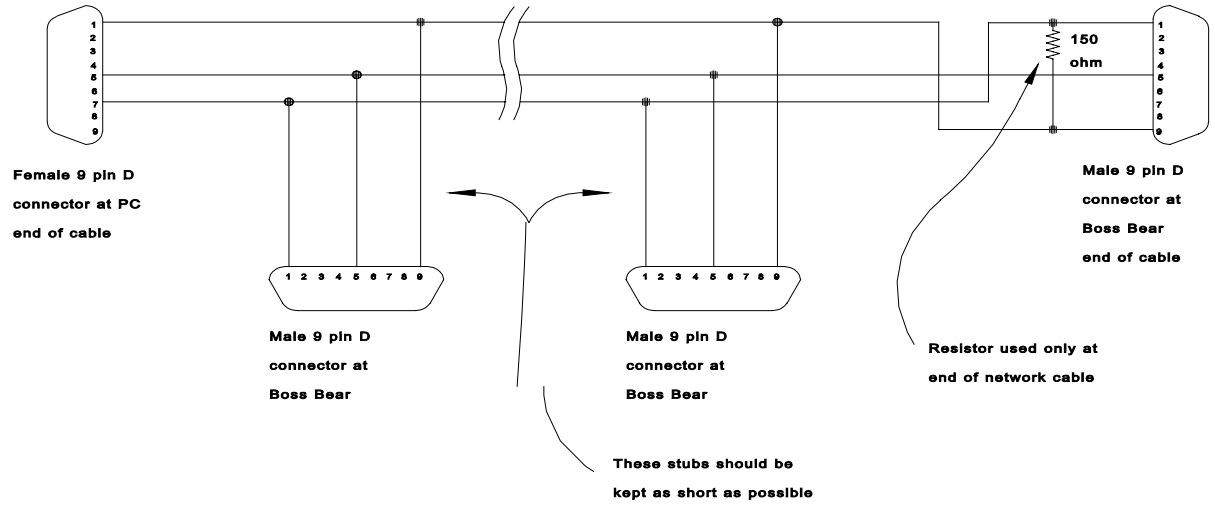


Figure 28 – Cable Drawing for Old Network Interface Card

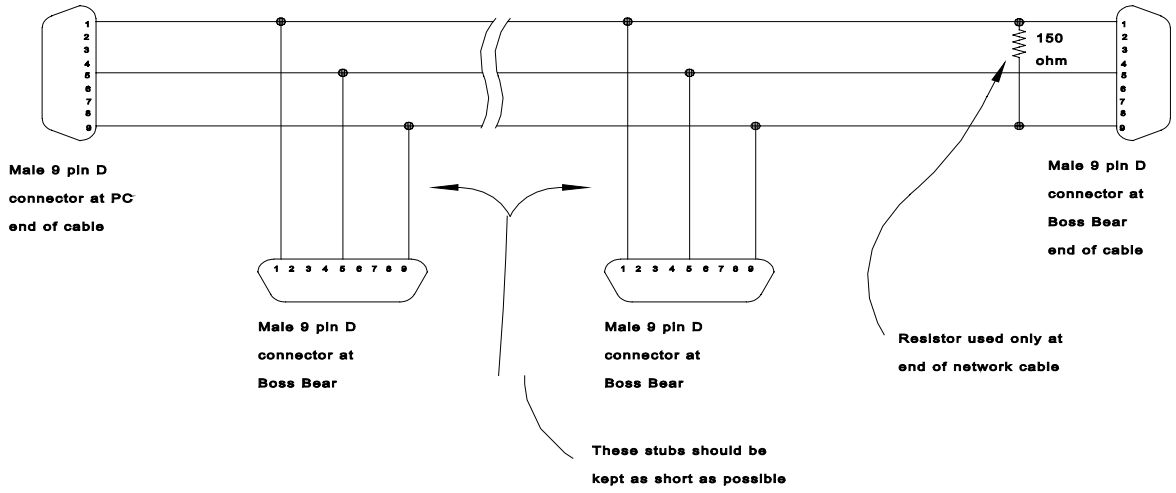


Figure 29 – Cable Drawing for Newer Network Interface Card

Chapter 11
Error Handling in Bear BASIC

There are several types of programming errors that can occur during the development cycle:

- Syntax errors. These occur when the programmer enters code which doesn't follow the required format of the language. The compiler catches these and displays an error message and the line number, making it simple to correct the problem. Examples of this include misspelled keywords (ie. PRNT instead of PRINT), incorrect number of arguments to a statement or function (ie. SETDATE 9,4,91 instead of SETDATE 9,4,91,4), and incorrect program format (ie. NEXT without corresponding FOR).
- Runtime errors caused by program implementation errors. These are mistakes made by the programmer in the coding of the program, that may or may not get caught by the Bear BASIC system while the program is running. An example of one that would get caught would be to declare an array of 10 elements and then try to access the 12th element, generating a "Subscript Out of Range" error; error checking would have to be enabled for this to get caught (see ERROR and NOERR). These errors can be extremely difficult to find and correct, especially if they occur in a section of code that is seldom executed.
- Runtime errors caused when an I/O device detects an error condition. An I/O error may or may not be important, depending upon the individual system.
- Logic errors in the design of the system. These can be the most difficult errors to correct, since they result from insufficient planning and incomplete understanding of the system operation. A fundamental logic error may not be detected until the system is in operation, but it may require that large portions of a program be rewritten.

In addition to detecting syntax errors during the program entry and compile phases, Bear BASIC provides facilities that allow the BASIC program to handle two types of errors at runtime: I/O errors and program errors. These are handled in different ways, so they are discussed separately.

The ERR function returns the latest error that was detected by Bear BASIC. Each time a new error occurs, it overwrites the previous error register value with the new error number. Each time that ERR is referenced, the error register is reset back to 0. The ERR function returns the following error numbers at runtime:

0	$0	No error
1	$1	Serial transmission timeout
2	$2	Failure programming EEPROM
16	$10	COM1 receive error (overrun, parity, framing)
17	$11	COM2 receive error (overrun, parity, framing)
256	$100	Undefined error
263	$107	Expression Error
264	$108	String Variable Error
266	$10A	Line Number Does Not Exist
267	$10B	Task Error
271	$10F	RETURN Without GOSUB
272	$110	Subscript out of Range
273	$111	Overflow
275	$113	Task Mismatch

276	$114	Function Error
277	$115	String Length Exceeded
280	$118	Illegal Print/Input Format
281	$119	String Space Exceeded
282	$11A	Illegal File Number
283	$11B	Improper Data to INPUT Statement
285	$11D	Data Statement Does Not Match Read
286	$11E	Failure Programming EPROM or EEPROM

11.1 I/O Errors

Some I/O devices detect errors periodically during their normal operation. On the Boss Bear, the serial ports are the prime example of this; in an electrically noisy environment, they may detect parity and framing errors frequently. These are not fatal errors which warrant stopping the program's execution, but they are important enough that the program will need to process the error appropriately. I/O errors can be handled by the programmer in two ways: using the ON ERROR statement and checking the ERR function periodically. There are four I/O errors that are detected with the Boss Bear v2.01 system software:

1	$1	Serial transmission timeout
2	$2	Failure programming EEPROM
16	$10	COM1 receive error (overrun, parity, framing)
17	$11	COM2 receive error (overrun, parity, framing)

The ON ERROR statement causes the program execution to proceed at a specified line number when an error is detected by one of the I/O functions. The following example demonstrates this:

```
100  INTEGER K
150  ONERROR 300                    ' Set up the error handler
200  FILE 0: K=GET                  ' Get a character from the console
210  FILE 6: PRINT CHR$(K);         ' Print it onto the onboard display
220  GOTO 200
300  FILE 6: PRINT "*** "; ERR      ' Error detected
310  GOTO 200
```

Line 150 sets up the error handler at line 300. If an error is detected when the GET function is called, then the program will jump to line 300. Line 300 will display the error number (returned by the ERR function), an jump back to line 200. Note that the error is not detected until an I/O operation is attempted; in this case, the GET function.

The ON ERROR statement has one important limitation: everything having to do with it must be in task 0. This includes the line containing the ON ERROR statement, the line referenced by the ON ERROR statement, and the I/O operations that may cause the error to be detected. If an I/O operation occurs in a task other than 0 and detects an error, then the program execution will continue without jumping to the line referenced by the ON ERROR statement; it will be as if no ON ERROR had occurred. If all of the serial I/O is performed within task 0, however, then ON ERROR can be quite useful. The ON ERROR

approach to error handling generally works best in programs that perform simple serial I/O operations.

I/O errors can also be handled by checking the ERR value periodically while performing I/O. This allows the programmer more control over the error detection, it doesn't change the program flow like ON ERROR does, and it isn't limited to just task 0. This approach works well in more complex serial applications, such as the packet-based communications protocols used by many intelligent sensors. In this type of communications, it may only be necessary to check the error status at the end of each packet, instead of after each character.

```
100  INTEGER K
200  FILE 0: K=GET                    ' Get a character from the console
210  FILE 6                           ' Set up to print to onboard display
220  IF ERR=16 THEN PRINT " Error "   ' Check for COM1 receive error
230  PRINT CHR$(K);                   ' Print the character
240  GOTO 200
```

This example just checks the value of ERR after every character is received, in line 220. If a receive error has occurred on COM1, then ERR will return a 16 ($10), causing line 220 to print "Error".

11.2 Program Errors

Bear BASIC performs error checking while the program is running, if error checking is enabled (see ERROR and NOERR). If a program error occurs, Bear BASIC will normally print an error message to the console (COM1 serial port) and return to the command prompt. During the initial debugging this is an acceptable response. During system testing, or especially after the system is installed, this can be very inconvenient, for two reasons. First, if there isn't a terminal attached to COM1 then the error message will be lost. Second, stopping the program at the instant that the error is detected may leave the system in an unacceptable state.

To solve these problems, the Bear BASIC programmer can get access to the program error handler by modifying the vector at $0013. By using JVECTOR, the program can be made to jump to a task when a program error is detected; this task should be treated as a hardware interrupt task. This task can put the system into a safe state and store the error number in a variable (or perhaps in EEPROM). The task must either stop the program (with the STOP statement) or restart the program (by using CALL $100); a program error indicates that an unrecoverable problem has occurred, so it isn't possible to continue running the program.

```
100  INTEGER K
110  STRING A$(25)
150  JVECTOR $13,1                    ' Set up error handler task
200  A$=""
210  FOR K=1 TO 26
220  A$=CONCAT$(A$,CHR$(K+64))        ' Fill string with ASCII letters
230  NEXT K
240  PRINT "Done.": STOP
500  TASK 1
510  FILE 6                           ' Display error message on onboard display
```

```
520  PRINT "Error "; ERR            ' Display error number
530  STOP                           ' Stop program execution
```

This example causes a program error to occur when, in line 220, it accesses the 26th character in A$, which is only declared to be 25 characters long. Line 150 has set up task 1 to handle program errors, so when the error occurs, task 1 prints the error number. When this program is run, it will display "Error 277", which is the "String Length Exceeded" error. In general, the PRINT and FPRINT statements shouldn't be used inside of an interrupt task (which includes this error handler task), because they re-enable the interrupts and let the multitasking to continue, either of which could cause the system to lock up, depending upon what the other tasks are doing. In this example, however, the rest of the program isn't doing anything, so this won't cause a problem.

Appendix A
Specifications

Boss Bear Hardware

Processor:	Z180 operating at 6.144MHz
System PROM:	64K/128K
System RAM:	128K
System EEPROM:	nonvolatile storage: 2K/8K
User EPROM:	32K/128K
Serial port 1:	RS232 levels 300BPS to 38.4KBPS 7 or 8 data bits 1 or 2 stop bits None, even, or odd parity XON/XOFF handshaking
Serial port 2:	RS232, RS422, or RS485 levels 300BPS to 38.4KBPS 7 or 8 data bits 1 or 2 stop bits None, even, or odd parity XON/XOFF handshaking RS485 supports network of up to 32 nodes without repeater Leakage +/- 1□A Dynamic Impedance: 1.6M @ 1KHz, 1.6K @ 1000KHz
A/D:	8 channels 12 bit resolution 0 to 5 VDC input Approximately 350 microseconds per BASIC conversion
Counter:	Single channel 24 bit binary up/down counter Support for quadrature X1 and X4 mode Open collector input circuitry Selectable input filtering: none, 20Hz, 5KHz, 100 KHz High speed open collector direct output Sensor power supply: 5 VDC regulated or 12VDC @ 100mA unregulated

Display: Three types of alphanumeric display are available as an option
1. LCD: 2 lines by 40 characters
2. Backlit LCD: 2 lines by 40 characters
3. Vacuum Fluorescent: 2 lines by 40 characters

Keyboard: 20 key membrane keypad: 0-9, ENTER, CLEAR, F1-F8

Discrete Input/Output: Up to 128 inputs and 128 outputs using standard Divelbiss Bear Bones I/O panels, which are available in a variety of configurations.

Bear Bones Interface: Direct interface to Bear Bones I/O bus, providing multiprocessor capability.

Real Time Clock: Battery backed up, providing year, month, day, hour, minute, and second.

Expansion Connectors: 3 expansion bus connectors allow optional I/O modules to be added by the user.

Operating Temperature: 0 to 60 degrees C

Power Requirements: Input voltage - 115 VAC, 10 VAC, or 12 VDC

Model	Max Primary i at 120 VAC	Max Secondary i at 10 VAC	Secondary I at 12 VDC
VFD	200 mA AC	1.1 A AC	1.0 A DC
LCD	35 mA AC	152 mA AC	130 mA DC
Backlit LCD	130 mA AC	540 mA AC	460 mA DC
No display	32 mA AC	140 mA AC	120 mA DC

Size: Subplate mounted unit: 8" x 11" x 2"
Panel mounted unit: 8" x 12" x 2"

Bear BASIC Compiler

Language: Compiled BASIC with enhancements

Memory Available: 29K for BASIC source code
42K at runtime for compiled code and variable storage
40K at runtime for extra data storage

Multitasking: Supports up to 32 tasks
Preemptive context switcher; switches tasks 100 times/second

Variables:	Up to 128 variables in a program 7 character variable names Supports INTEGER, REAL, and STRING types Supports one and two dimensional arrays
User Defined Functions:	Allows user to add extensions to BASIC Up to 64 user defined functions in a program

Appendix B
Error Messages

The following error messages may be displayed by Bear BASIC on the console terminal. If the error is associated with a line number in the BASIC program, then a line number will be displayed before the error message. When an error occurs, Bear BASIC returns to the compiler prompt after displaying the error message.

`*** BAD INPUT. PLEASE RE-ENTER ***`

Displayed at runtime if the data entered in response to an INPUT statement doesn't match the arguments given. Just retype the input data properly. This error can be avoided by using the FINPUT statement.

`Data Statement Does Not Match Read`

Occurs when a READ or RESTORE is encountered, but no DATA statements have been found. All DATA statements must be before the first READ.

`Expression Error`

Occurs when a mathematical expression has been formatted incorrectly.

`Failure Programming EPROM or EEPROM`

Indicates that a byte didn't verify correctly after being programmed in either the EPROM (EPROM SAVE, EPROM COMPILE CODE commands) or the EEPROM (EEPOKE statement).

`File not Found`

EPROM file not found.

`File Verify Failure`

An error was detected after writing a file to the EPROM.

`Function Error`

Occurs when a program is compiled if the function had an argument in the wrong mode, or if the wrong number of arguments were given for the function. At runtime, a FUNCTION ERROR may appear if the argument to a function is out of range, for example, if the square root of a negative number is taken.

`Illegal Direct Command`

Occurs if an unknown direct command is entered.

`Illegal File Number`

On EPROM LOAD [*filenum*] command, this error occurs when the specified [*filenum*] is not present on the EPROM.

`Illegal Print/Input Format`

Is displayed at runtime if the format given in an FPRINT or FINPUT statement does not match the number of arguments in the FPRINT/FINPUT statement (if there are more things to be printed/input than there are formats), or if the format specified is not correct.

`Improper Data to INPUT Statement`

Occurs when data is being read from a file and the data doesn't match the arguments of the INPUT statement.

`Insufficient EPROM Space`

The user's EPROM is full.

`Line Number Does Not Exist`

Occurs if a line number is referenced in a GOTO, GOSUB, or IF statement and that line cannot be found.

`Line Number Error`

Occurs when an illegal line number is used. Line numbers must be integers from 1 to 32,767.

`Misuse of String Expression`

Occurs when a string expression is used in a place where a real or integer expression is needed, or if a real or integer expression is used in lieu of a string.

`No Compiled Code`

Occurs when the GO command is issued but there is no compiled code to execute. If any change is made to the program, it must be recompiled.

`Not Enough Memory to Compile Program`

This can be issued under two circumstances. First, the compiled code and variable space may be too large; try shrinking arrays, compiling with NOERR, and using subroutines to eliminate duplicate code. Second, the source code may be too large, which doesn't leave enough room for the compiler's temporary storage; try removing comments to save space.

`Not in Program Mode`

EPROM SAVE was executed while SW1 was in the **RUN** mode. Switch it to **PROG** and issue the command again.

`Overflow`

Indicates that a math overflow occurred, such as divide by 0, LOG of a negative number, etc.

`PROM is incompatible with this Compiler Version`

This occurs when a program on the user's EPROM is executed on power up or from a CHAIN statement. The compiled code on the user's EPROM was created with a previous version of the Bear BASIC software. Load the source code, recompile the program, and save it onto a new EPROM (don't forget to set **JW3** correctly).

`Quote or Parenthesis Mismatch`

Occurs when a program is being entered and a line with an odd number of parenthesis or double quotes is found.

`RETURN Without GOSUB`

Occurs during program execution if a RETURN is encountered when no GOSUB is active. All GOSUBs must have a corresponding RETURN.

`Statement Formed Poorly`

Occurs when a statement is entered that does not conform to the syntax rules for Bear BASIC.

`Statement Ordering Error`

Occurs if an INTEGER, REAL, or STRING statement appears after executable statements in the program.

`String Length Exceeded`

Occurs when a string exceeds 127 characters or a string variable exceeds the maximum size assigned to it in the STRING statement.

`String Space Exceeded`

Occurs if one line of the program requires too many string temporaries to evaluate. Try splitting the line into several simpler ones.

`String Variable Error`

Displayed when a variable is used incorrectly, for example, if a string is used as a real or integer.

`Subscript out of Range`

Occurs if the subscript of a dimensioned variable exceeds the range assigned in an INTEGER or REAL statement.

`Task Error`

can be caused by any of the following:

- receiving a hardware interrupt which was vectored to a non-existent task.
- trying to RUN a non-existent task.
- trying to RUN TASK 0.
- trying to use more than 31 TASK statements.

`Task Mismatch`

Internal task error.

`Too many FOR statements`

More than 255 FOR statements found.

`Too Many Variables`

More than 128 variable declarations found.

`Undefined error`

Internal compiler error.

`Undefined Variable`

Occurs during compilation if a variable is encountered which was not defined in an INTEGER, REAL or STRING statement.

`Unmatched FOR..NEXT Pair`

Occurs during execution of a program if a NEXT is found without a FOR.

`Unrecognizable Statement`

Occurs when a statement is entered that does not conform to the syntax rules for Bear BASIC.

Appendix C
Hardware Description

The information in this appendix is presented for the more advanced Boss Bear users that would like to access the hardware directly. It will also be of interest to anyone that is curious about the Boss Bear hardware architecture. The information is not presented in any particular order. This is not intended to be a tutorial on the use of the hardware; it is assumed that the reader has the background to be able to understand and use the information.

In this appendix, hexadecimal numbers will be represented with a trailing 'H'; for example: 00H, 3EH, 0D7H, 2000H, 0FF00H, or 20345H.

C.1 The Z180 Processor

The Boss Bear is based around the Zilog Z180 microprocessor. This is an enhanced version of the Zilog Z80, which is one of the most widely used microprocessors. This chip is also available as the Hitachi 64180. Both of these manufacturers can supply data books that describe the chip in detail; the information presented here is a brief overview of the chip's operation. The general features of the processor are as follows:

- 8 bit microcoded CMOS microprocessor
- 512 KB physical address space
- 64 KB logical address space. An integrated memory management unit translates logical to physical addresses.
- 64 KB physical I/O address space
- a two channel DMA controller
- programmable wait state generator
- provides DRAM refresh signals
- two channel asynchronous serial communications interface
- one channel synchronous serial interface
- two channel 16 bit programmable reload timer
- fixed priority interrupt controller manages four external and 8 internal interrupt sources

Not all of these features are used in the Boss Bear; for instance, there isn't any need for the DMA controller, since there aren't any I/O devices that need to transfer large amounts of data.

C.2 I/O Address Map

The Z180 supports a 16 bit I/O address bus. The first 40H bytes are taken up by I/O registers that are internal to the Z180; these must be accessed with the I/O address high byte set to 0. I/O addresses from 40H to 0FFH are decoded by hardware outside of the processor; only the low 8 bits of the I/O address are decoded. The following is a partial list of I/O registers; it is unlikely that some of the registers (such as the DMA control registers)

will be accessed on the Boss Bear. The reader is referred to the manufacturer's data books for complete information on the I/O registers.

	ASCI control register A channel 0	CNTLA0	00H
	ASCI control register A channel 1	CNTLA1	01H
	ASCI control register B channel 0	CNTLB0	02H
	ASCI control register B channel 1	CNTLB1	03H
ASCI	ASCI status register channel 0	STAT0	04H
	ASCI status register channel 1	STAT1	05H
	ASCI transmit data register channel 0	TDR0	06H
	ASCI transmit data register channel 1	TDR1	07H
	ASCI receive data register channel 0	RDR0	08H
	ASCI receive data register channel 1	RDR1	09H
CSI/O	CSI/O control register	CNTR 0AH	
	CSI/O transmit/receive data register	TRDR 0BH	
	Timer data register channel 0 low	TMDR0L	0CH
	Timer data register channel 0 high	TMDR0H	0DH
	Reload register channel 0 low	RLDR0L	0EH
	Reload register channel 0 high	RLDR0H	0FH
Timer	Timer control register	TCR	10H
	Timer data register channel 1 low	TMDR1L	14H
	Timer data register channel 1 high	TMDR1H	15H
	Reload register channel 1 low	RLDR1L	16H
	Reload register channel 1 high	RLDR1H	17H
Misc.	Free running counter	FRC	18H
Interrupts	Interrupt vector low register	IL	33H
	INT/TRAP control register	ITC	34H
Refresh	Refresh control register	RCR	36H
	MMU common base register	CBR	38H
MMU	MMU bank base register	BBR	39H
	MMU common/bank area register	CBAR 3AH	
I/O	Operation mode control register	OMCR	3EH
	I/O control register	ICR	3FH

The remaining I/O space (40H to 0FFH) is decoded by the Boss Bear hardware:

Onboard counter interrupt reset	CSRCNT	40H
Expansion connector J3	CSEXP1	80H-9FH
Expansion connector J4	CSEXP2	A0H-BFH
Expansion connector J5	CSEXP3	C0H-DFH

C.3 Interrupts

The Z180 has twelve interrupt sources, four external and eight internal, with fixed priority. The priorities are as follows, listed from highest to lowest priority:

Highest priority	1	TRAP (undefined op-code trap)	Internal
	2	NMI (Non-Maskable Interrupt)	External
	3	INT0 (maskable interrupt level 0)	External
	4	INT1 (maskable interrupt level 1)	External
	5	INT2 (maskable interrupt level 2)	External
	6	Timer 0	Internal
	7	Timer 1	Internal
	8	DMA channel 0	Internal
	9	DMA channel 1	Internal
	10	CSIO (Clocked Serial I/O port)	Internal
	11	ASCI0 (serial channel 0)	Internal
Lowest priority	12	ASCI1 (serial channel 1)	Internal

Interrupt Vectors

The processor has different methods of vectoring to the interrupt service routines for each of the interrupt sources. The current program counter value is always PUSHed onto the stack, regardless of interrupt type. The TRAP interrupt vectors to logical address 0000H; the code can examine the TRAP bit of the ITC register to determine if a TRAP interrupt or RESET occurred. The NMI vectors to logical address 0066H. INT0 vectors to 0038H; INT0 also supports two other modes of operation that aren't useful with the Boss Bear hardware. All of the other interrupts are vectored through the interrupt vector table, which is located at 00E0H on the Boss Bear. The table consists of the addresses of the interrupt service routines; it is 9 entries of 2 bytes each.

00E0H	INT1
00E2H	INT2
00E4H	Timer 0
00E6H	Timer 1
00E8H	DMA channel 0
00EAH	DMA channel 1
00ECH	CSIO
00EEH	ASCI0
00F0H	ASCI1

INT/TRAP Control Register

The ITC (INT/TRAP Control) register is used to handle TRAP interrupts and to enable or disable the external maskable interrupt inputs INT0, INT1, and INT2.

ITC: I/O Address 34H

7	6	5	4	3	2	1	0
TRAP	UFO	---	---	---	ITE2	ITE1	ITE0
R/W	R				R/W	R/W	R/W

TRAP The processor sets this bit to 1 when an undefined op-code is fetched.
UFO Used in conjunction with TRAP to determine the starting address of the undefined instruction.
ITE2 Set this bit to enable external interrupt 2.
ITE1 Set this bit to enable external interrupt 1.
ITE0 Set this bit to enable external interrupt 0.

Non-Maskable Interrupt

When a falling edge occurs at the NMI input, the current PC is pushed onto the stack and execution commences at logical address 0066H. The last instruction of the NMI service routine should be RETN, in order to restore the interrupt state that existed before the NMI occurred.

External Interrupt 0

INT0 is a the second highest priority external interrupt (after NMI); it is triggered by a low level on the INT0 line. On the Boss Bear, INT0 is attached to the J3 expansion connector. INT0 is masked when a DI instruction is executed (which disables all maskable interrupts), or by clearing the ITE0 bit in the ITC register. INT0 has three interrupt response modes; in the Boss Bear, it should always be set to mode 1 with the IM 1 instruction. When a low level is applied to the INT0 line, the current PC is pushed onto the stack and execution commences at logical address 0038H. The INT0 service routine should end with the EI instruction followed by RETI, so that the interrupts are re-enabled.

External Interrupt 1

INT1 is the third highest priority external interrupt; it is triggered by a low level on the INT1 line. On the Boss Bear, INT1 is attached to the J3 and J4 expansion ports, and to the real time clock. INT1 is masked when a DI instruction is executed (which disables all maskable interrupts), or by clearing the ITE1 bit in the ITC register. When a low level is applied to the INT1 line, the current PC is pushed onto the stack and execution commences at the logical address that is found at location 00E0H (ie. it is an indirect reference). The INT1 service routine should end with the EI instruction followed by RETI, so that the interrupts are re-enabled.

External Interrupt 2

INT2 is the lowest priority external interrupt; it is triggered by a low level on the INT2 line. On the Boss Bear, INT2 is attached to the onboard high speed counter. The counter interrupt is latched by a flip-flop; an OUT to I/O location 40H (with any value) resets this flip-flop. INT2 is masked when a DI instruction is executed (which disables all maskable

interrupts), or by clearing the ITE2 bit in the ITC register. When a low level is applied to the INT2 line, the current PC is pushed onto the stack and execution commences at the logical address that is found at location 00E2H (ie. it is an indirect reference). The INT2 service routine should end with the EI instruction followed by RETI, so that the interrupts are re-enabled.

Internal Interrupts

The internal interrupts (except for TRAP) use the same vectored response mode as INT1 and INT2. When one of the interrupt conditions occurs, the current PC is pushed onto the stack and execution commences at the logical address that is found at the corresponding vector location (between 00E4H and 00F0H). The interrupt service routine should end with the EI instruction followed by RETI, so that the interrupts are re-enabled. The internal interrupts are described independently below.

C.4 Asynchronous Serial Communications Interface

The two independent ASCI channels on the Z180 are configurable to cover the majority of asynchronous serial interface possibilities. Each channel is double buffered and has its own configuration registers.

ASCI Transmit Data Register 0, 1

Data is written into TDR0 (I/O address 06H) or TDR1 (I/O address 07H) to be sent over the corresponding serial channel. The data is moved from this register into a shift register to be transmitted; therefore, it could take up to 2 character times for this byte to be transmitted. When TDRx is emptied, the corresponding TDRE bit is set and the ASCIx interrupt is generated if the TIE bit is set.

ASCI Receive Data Register 0, 1

RDR0 (I/O address 08H) and RDR1 (I/O address 09H) hold the incoming data bytes. When a byte is received into RDRx, the RDRF bit is set and the ASCIx interrupt is generated if the RIE bit is set.

ASCI Status Register 0, 1

Each channel has a status register that indicates the ASCI communication, error, and modem control signal status. It also controls the interrupt state for the ASCI channel.

STAT0: I/O Address 04H

7	6	5	4	3	2	1	0
RDRF	OVRN	PE	FE	RIE	DCD0	TDRE	TIE
R	R	R	R	R/W	R	R	R/W

STAT1: I/O Address 05H

7	6	5	4	3	2	1	0
RDRF	OVRN	PE	FE	RIE	CTS1E	TDRE	TIE
R	R	R	R	R/W	R/W	R	R/W

RDRF Receive Data Register Full. Set to 1 when an incoming data byte is loaded into RDR. Note that if a framing or parity error occurs, RDRF is still set and the receive data (which generated the error) is still loaded into RDR. RDRF is cleared to 0 by reading RDR.

OVRN Overrun. Set to 1 when RDR is full and another data bye is received. OVRN is cleared to 0 when the EFR bit is written to 0.

PE Parity Error. Set to 1 when parity detection is enabled and a parity error is detected on an incoming data byte. PE is cleared to 0 when the EFR bit is written to 0.

FE Framing Error. Set to 1 when a framing error (invalid stop bit) is detected. FE is cleared to 0 when the EFR bit is written to 0.

RIE Receive Interrupt Enable. Set to 1 to enable ASCI receive interrupts. When enabled, if any of the flags RDRF, OVRN, PE, or FE become set to 1, then an interrupt request will be generated.

DCD0 Channel 0 Data Carrier Detect. On the Boss Bear, this will always read 0.

CTS1E Channel 1 CTS Enable. Set to 1 to enable the CTS line for channel 1.

TDRE Transmit Data Register Empty. Set to 1 when TDR has been emptied to indicate that the next transmit data byte can be written to TDR. After a byte is written to TDR, TDRE is cleared to 0 until the ASCI transfers the byte into the transmit shift register, when TDRE will be set to 1 again. Note that when the shift register is already empty, TDRE will be set within microseconds; when the shift register is full, however, it will take up to one character time for TDRE to be set.

TIE Transmit Interrupt Enable. Set to 1 to enable ASCI transmit interrupts. When enabled, an interrupt will be generated when TDRE = 1.

ASCI Control Register A 0,1

Each channel Control Register A configures the major operating modes.

CNTLA0: I/O Address 00H

7	6	5	4	3	2	1	0
MPE	RE	TE	RTS0	EFR	MOD2	MOD1	MOD0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CNTLA1: I/O Address 01H

7	6	5	4	3	2	1	0
MPE	RE	TE	CKA1D	EFR	MOD2	MOD1	MOD0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

MPE Multi Processor mode Enable. A 1 will enable the multiprocessor communication mode. Normally cleared to 0 on the Boss Bear.

RE Receiver Enable. A 1 enables the ASCI receiver. A 0 disables the receiver and interrupts any receive operation in progress.

TE Transmitter Enable. A 1 enables the ASCI transmitter. A 0 disables the transmitter and interrupts any transmit operation in progress.

RTS0 Request To Send channel 0. A 0 causes the RTS0 output line to go low (active). A 1 causes the RTS0 line to immediately go high (inactive).

CKA1D CKA1 Clock Disable. Normally cleared to 0 on the Boss Bear.

EFR Error Flag Reset. When written with 0, resets all ASCI error flags (OVRN, FE, PE) to 0; this must be done any time that an error is detected by the ASCI channel. When read, returns the value of the multiprocessor bit for the last receive operation; this feature is not normally used on the Boss Bear.

MOD2 ASCI Data Format Mode 2. A 1 selects 8 bit data; 0 selects 7 bit data.

MOD1 ASCI Data Format Mode 1. A 1 enables parity; 0 disables parity.

MOD0 ASCI Data Format Mode 0. A 1 selects 2 stop bits; 0 selects 1 stop bit.

ASCI Control Register B 0,1

Each channel Control Register A configures parity and baud rate.

CNTLB0: I/O Address 02H

7	6	5	4	3	2	1	0
MPBT	MP	CTS/PS	PEO	DR	SS2	SS1	SS0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CNTLB1: I/O Address 03H

7	6	5	4	3	2	1	0
MPBT	MP	CTS/PS	PEO	DR	SS2	SS1	SS0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

MPBT Multi Processor Bit Transmit. Not normally used on the Boss Bear.

MP Multi Processor Mode. Normally cleared to 0 on the Boss Bear.

CTS/PS Clear To Send/Prescale. When read, returns the state of the external CTS input pin; if the pin is high, CTS/PS will be read as a 1. When the CTS input

pin is high, the TDRE bit is inhibited. For ASCI channel 1, the CTS input is only valid if the CTS1E bit is set to 1. When written, CTS/PS specifies the baud rate generator prescale factor; a 1 selects prescale by 30 while a 0 selects prescale by 10.

PEO — Parity Even Odd. A 1 selects odd parity; a 0 selects even parity.

DR — Divide Ratio. Specifies the baud rate data sampling divider; a 1 selects divide by 64 while a 0 selects divide by 16.

SS2,1,0 — Speed Select 2, 1, 0. Specifies the data clock source (internal or external) and baud rate prescale factor, according to the following table:

SS2	SS1	SS0	Divide Ratio
0	0	0	÷1
0	0	1	÷2
0	1	0	÷4
0	1	1	÷8
1	0	0	÷16
1	0	1	÷32
1	1	0	÷64
1	1	1	use external clock

C.5 Clocked Serial I/O Port

This is a simple, high speed synchronous serial I/O port. On the Boss Bear, it is not used at all as a serial port; the Transmit Data line (TXS) is used to control the RS-485 driver direction.

CSI/O Transmit/Receive Data Register

TRDR (I/O address 0BH) is used for both CSI/O transmission and reception, which means that transmission and reception can't occur simultaneously.

CSI/O Control/Status Register

CNTR is used to monitor and control the operation of the CSI/O.

CNTR: I/O Address 0AH

7	6	5	4	3	2	1	0
EF	EIE	RE	TE	---	SS2	SS1	SS0
R	R/W	R/W	R/W		R/W	R/W	R/W

EF — EF is set to 1 by the CSI/O to indicate completion of an 8 bit data transmit or receive operation. If EIE is 1 when EF is set to 1, then a CPU interrupt request will be generated.

EIE — End Interrupt Enable. EIE should be set to 1 to enable EF to generate a CPU interrupt request.

RE — Receive Enable. A CSI/O receive operation is started by setting RE to 1. From that point, a data bit is shifted in 2 □sec after each data clock falling edge.

TE — Transmit Enable. A CSI/O transmit operation is started by setting TE to 1. From that point, a data bit is shifted out on each data clock falling edge.

SS2,1,0 — Speed Select 2, 1, 0. Specifies the CSI/O data clock source (internal or external) and baud rate prescale factor, according to the following table:

SS2	SS1	SS0	Divide Ratio	Baud Rate
0	0	0	÷20	307200
0	0	1	÷40	153600
0	1	0	÷80	76800
0	1	1	÷160	38400
1	0	0	÷320	19200
1	0	1	÷640	9600
1	1	0	÷1280	4800
1	1	1	use external clock	

C.6 Programmable Reload Timer

The Z180 contains a two channel, 16 bit Programmable Reload Timer. Each PRT channel consists of a 16 bit down counter and a 16 bit reload register, both of which can be directly read and written. The down counter overflow can be programmed to generate a CPU interrupt request. Both PRT channels use an input clock that is the system clock (6.144 MHz) divided by 20, or 307200 Hz.

Timer Data Register

PRT0 and PRT1 each have a 16 bit Timer Data Register: TMDR0 (I/O address 0CH and 0DH) and TMDR1 (I/O address 14H and 15H). TMDR is decremented once each 20 system clocks (every 3.255 □sec). When TMDR counts down to 0, it is automatically reloaded with the value contained in the Reload Register (RLDR).

In order to ensure that the correct count value is read when the counter is running, TMDR must be read low byte followed by high byte. If the counter is not running (TDE is 0), then TMDR can be read in either order. TMDR can be written in either order, but the counter must be inhibited using the TDE bit.

Timer Reload Register

PRT0 and PRT1 each have a 16 bit Timer Reload Register: RLDR0 (I/O address 0EH and 0FH) and RLDR1 (I/O address 16H and 17H). When TMDR counts down to 0, it is automatically reloaded with the contents of RLDR.

Timer Control Register

TCR is used to monitor and control the operation of both PRT channels.

TCR: I/O Address 10H

7	6	5	4	3	2	1	0
TIF1	TIF0	TIE1	TIE0	TOC1	TOC0	TDE1	TDE0
R	R	R/W	R/W	R/W	R/W	R/W	R/W

TIF1 Timer Interrupt Flag 1. When TMDR1 decrements to 0, TIF1 is set to 1. This can generate an interrupt request if enabled by TIE. TIF1 is reset to 0 when TCR is read and then either byte of TMDR1 is read.

TIF0 Timer Interrupt Flag 0. When TMDR0 decrements to 0, TIF0 is set to 1. This can generate an interrupt request if enabled by TIE. TIF0 is reset to 0 when TCR is read and then either byte of TMDR0 is read.

TIE1 Timer Interrupt Enable Flag 1. When TIE1 is set to 1, TIF1 will generate a CPU interrupt request. When TIE1 is cleared to 0, the interrupt request is inhibited.

TIE0 Timer Interrupt Enable Flag 0. When TIE0 is set to 1, TIF0 will generate a CPU interrupt request. When TIE0 is cleared to 0, the interrupt request is inhibited.

TOC1,0 Timer Output Control 1, 0. TOC1 and TOC0 must be 0 on the Boss Bear.

TDE1 Timer Down Count Enable 1. TDE1 controls down counting for TMDR1; a 1 enables down counting, while a 0 disables it.

TDE0 Timer Down Count Enable 0. TDE0 controls down counting for TMDR0; a 1 enables down counting, while a 0 disables it.

C.7 Free Running Counter

The FRC (I/O address 18H) is a read only 8 bit free running counter which decrements every 10 system clock cycles (every 1.628 □sec).

Appendix D
Using Assembly Language Subroutines

This appendix discusses the use of assembly language subroutines within Bear BASIC programs. Assembly language is the native mode of the microprocessor, with each line of code corresponding to a single machine code instruction which executes in about a microsecond. Assembly language can produce the fastest, smallest programs, but it is more difficult to learn and slower for the programmer to use. Often the best compromise is to write most of a program in a high level language (such as Bear BASIC or C), and write the time critical sections in assembly language.

In order to write assembly language subroutines for the Boss Bear, the programmer must have a cross-assembler program for the Z80 or Z180 processor. This is a program which runs on a personal computer and converts the assembly language source code into Z180 machine code. The Divelbiss applications engineers can recommend an assembler program, based on the customers requirements.

It is possible to call assembly language subroutines with all versions of the Boss Bear. The CALL, CODE, and SYSTEM statements have been in every version since 1.00. However, version 2.03 will include several features that will make it much easier to integrate assembly language into a Bear BASIC program.

D.1 Storing Assembly Routines

Obviously, the subroutine must be stored somewhere in memory before it can be called. There are several possibilities available, depending upon the size of the code and whether it is relocatable. The code is actually stored in memory by READing it from DATA statements and POKEing it into memory, or by using the CODE statement.

The subroutine can be stored in the unused space between the end of the user's compiled code and the start of the user's variables. These addresses are given by the STAT command, as "End" and "Variable". Care must be taken when the program is modified, to ensure that the address range used is still valid, in case the "End" or "Variable" values change. This method has the advantage that the code doesn't have to be relocatable, so it is preferred when writing large subroutines. Of course, this method will only work if there is enough free space to store the subroutine; a very large BASIC program may not leave enough space.

The subroutine can be stored in the unused space between $FB00 and $FDFF. In version 2.00 and 2.01 of the Bear BASIC system software, this space is unused at runtime. This area is overwritten when the compiler is executed, but not during runtime. It isn't initialized, even during a CHAIN, so one program can load the code into memory, then chain to another program which will call the assembly routines. Divelbiss will attempt to leave this space available in future versions. This method is desirable because the code doesn't have to be relocatable.

The code can be stored inline with the CODE statement. This requires that the code be relocatable, since there is no way of predicting what address it will be stored at. This works best for simple, short subroutines.

If the BASIC program is very large, and the assembly portion is also large, then the assembly portion can be stored in another memory bank, and then called using a small routine that is in the BASIC runtime bank. At runtime, the Boss Bear doesn't use all of the 128K RAM, allowing data or assembly routines to be stored in the unused memory banks. This is a very sophisticated technique that should be used only by experienced programmers that fully understand the Z180 bank switching architecture. Interrupts must be turned off while executing out of another bank. This method allows very large programs to be written, and the assembly subroutines don't need to be relocatable.

If the code is relocatable and the programmer doesn't want to risk storing it at a fixed location, then it can be stored in an array or a string. This is the time honored way of storing assembly language subroutines in a BASIC program. This frees the programmer from having to check whether the chosen location is still unused after making each program change. In the Boss Bear, however, it is usually easier to store the code at $FB00.

If more than one assembly routine is being used, then it is a good idea to build a jump table to provide indirect access to each routine. This will allow the assembly language code to be modified without requiring that the addresses be changed in the BASIC program. For example, if a program has four assembly language routines stored in the $FB00 region, then the first 12 bytes would contain the jump table:

```
            ORG   $FB00
            JP    ROUTINE_1
            JP    ROUTINE_2
            JP    ROUTINE_3
            JP    ROUTINE_4

ROUTINE_1:  ; Code for assembly routine 1 goes here.
```

To call the second routine (ROUTINE_2), the BASIC code could execute `CALL $FB03`. This way, regardless of where ROUTINE_2 ends up being stored, the BASIC code won't need to be changed.

D.2 Calling an Assembly Routine

Once the assembly code is loaded in memory (but not before!) it can be called from BASIC with the CALL or SYSTEM statements. If the code is stored inline using the CODE statement, then it doesn't need to be called, since it will be executed when BASIC gets to that line during execution. Each method of calling subroutines (CODE, CALL, and SYSTEM) has different strengths and weaknesses.

CODE is the simplest to use from the BASIC standpoint, since the code doesn't have to be POKEd into memory. However, the assembly code must be relocatable, and arguments must be passed using fixed RAM locations (ie. POKEd into $FB00).

CALL is very easy to use from the BASIC standpoint, since arguments are passed as BASIC variables (ie. CALL $A000,J,A$). From the assembly standpoint, though, it takes several lines of code to get load and store the arguments, especially if the code is written to

handle all of the possible input combinations (integers, reals, strings, and being called with the wrong number of arguments).

SYSTEM is harder to use from the BASIC viewpoint, since arguments must be stored in an integer array before executing the SYSTEM statement. From the assembly viewpoint, though, this is very simple to program with. On entry, the registers hold the input values, and whatever is in the registers when the RET instruction is executed is passed back to BASIC.

The following points are valid regardless of which method is used (CODE, CALL, or SYSTEM):

- No registers need to be saved during the assembly routine.
- The Z180 alternate register set MAY NOT be used. An attempt to use any of the alternate registers will almost certainly lock up the Boss Bear.
- There is a small amount of stack space available to the assembly routine; it should limit its stack usage to 12 bytes (not including the return address, which is already on the stack).

D.3 Examples

D.3.1 CODE Example

The code statement lends itself to short routines that only need to be used at one spot in a BASIC program. A good example of this would be a bit reversal routine. Some equipment will transfer bits in the opposite order from the way that the Boss Bear stores them; it is very time consuming to reverse the bits in BASIC, but it is relatively fast in assembly language. The following assembly language source code performs this reversal. It takes an integer (16 bit) argument that is passed using location $FB00; it reverses the bits in this integer and returns the result at location $FB00.

```
ARG_ADDR    EQU         0FB00H

            LD          HL,(ARG_ADDR)           ; Get input argument
            LD          B,16                    ; Set up loop counter

LOOP:       RR          H                       ; Rotate bits to the right
            RR          L                       ; ...out of input word
            RL          E                       ; Rotate bits to the left
            RL          D                       ; ...into output word
            DJNZ        LOOP                    ; Do all 16 bits
            LD          (ARG_ADDR),DE           ; Store result
            ; Note that there is no RET instruction.
```

When this routine is assembled and put into the BASIC program, it would look like this:

```
100  integer J, RD
     '
     ' Other code goes here
     '
     gosub 2200                    ' Get new RD value
     '
     ' Other code goes here
     '
     stop
```

```
2200 ' Subroutine to get a reading from other hardware.  Note that the
     ' reading is an integer, and must have its bits reversed to match
     ' the Boss Bear format.
     J=$1234                        ' Simulated value read from hardware
     wpoke $FB00,J                  ' Store for assembly language to access
     code $2A,$00,$FB               ' Assembly routine to reverse bits
     code $06,$10,$CB,$1C,$CB,$1D
     code $CB,$13,$CB,$12,$10,$F6
     code $ED,$53,$00,$FB
     RD=wpeek $FB00                 ' Load result into RD
     fprint "S2H4S5H4","J=",J,"  RD=",RD
     return
```

When this example is executed, it reverses the bits in the value $1234 (in binary, 0001001000110100) to get the result $2C48 (in binary, 0010110001001000). It produces the following output when run:

```
J=1234  RD=2C48
```

D.3.2 CALL Example

This example uses an assembly language routine to concatenate multiple strings together. It accepts two or more arguments, all of which must be strings. The first argument is the string that it will concatenate onto. The succeeding arguments are the strings that will get concatenated onto the first string, in the order that they are encountered.

```
      ORG   0FB00H
      POP   HL                ; Get argument table address
      LD    A,(HL)            ; Get variable type flag
      OR    A
      JR    Z,ARG_ERROR       ; Jump if no arguments
      CP    3
      JR    NZ,ARG_ERROR      ; Jump if not a string
      INC   HL
      LD    E,(HL)
      INC   HL
      LD    D,(HL)            ; DE is pointer to destination
      INC   HL
; Update DE so that it points to the first character past the end of the
; string.
      PUSH  DE                ; Save the pointer to the string
      LD    A,(DE)            ; Get length of string
      INC   DE                ; Point to first character of string
      LD    (LENGTH),A
      ADD   A,E
      LD    E,A
      LD    A,D
      ADC   A,0
      LD    D,A               ; DE now points past end of string
; Now loop through all arguments, concatenating each string onto the
; first one.
LOOP:
      LD    A,(HL)            ; Get variable type flag
      OR    A
      JR    Z,DONE            ; Jump if no more arguments
      CP    3
      JR    NZ,ARG_ERROR      ; Jump if not a string
      INC   HL
      LD    C,(HL)
      INC   HL
      LD    B,(HL)            ; BC is pointer to this string
      INC   HL
      PUSH  HL                ; Save argument table pointer
      LD    H,B
```

```
      LD    L,C
      LD    A,(HL)            ; Get string length
      ADD   A,(LENGTH)        ; Add to current length
      LD    (LENGTH),A
      LD    A,(HL)            ; Get string length again
      OR    A
      JR    Z,CONT            ; Jump if string is empty
      LD    C,A
      LD    B,0               ; BC is loop counter
      INC   HL                ; Point at first character of string
      LDIR                    ; Copy the string into the destination
CONT:
      POP   HL                ; Restore argument table pointer
      JR    LOOP              ; Copy next string

DONE:
      POP   DE                ; Get pointer to destination string
      LD    A,(LENGTH)
      LD    (DE),A            ; Store new string length
      INC   HL
      PUSH  HL                ; Push return address back on stack
      RET

ARG_ERROR:
      LD    E,08H             ; String variable error
      JP    0013H             ; Jump to the ERROR handler, which returns
                              ; ...to the command line

LENGTH:     DS    1
```

This program is assembled and put into a Bear BASIC program to be tested:

```
100  INTEGER J,K
110  STRING A$(100),B$(40),C$(30)
200  DATA $E1,$7E,$B7,$28,$41,$FE,$03,$20,$3D,$23,$5E,$23,$56
210  DATA $23,$D5,$1A,$13,$32,$4B,$FB,$83,$5F,$7A,$CE,$00,$57,$7E
220  DATA $B7,$28,$20,$FE,$03,$20,$24,$23,$4E,$23,$46,$23,$E5,$60
230  DATA $69,$3A,$4B,$FB,$86,$32,$4B,$FB,$7E,$B7,$28,$06,$4F,$06
240  DATA $00,$23,$ED,$B0,$E1,$18,$DC,$D1,$3A,$4B,$FB,$12,$23
250  DATA $E5,$C9,$1E,$08,$C3,$13,$00
290  DATA -1
300  J=$FB00                        ' Load the assembly routine at $FB00
310  READ K
320  IF K=-1 THEN 400
330  POKE J,K
340  J=J+1
350  GOTO 310
400  A$="This "                     ' Set up strings for test
410  B$="a test"
420  C$=" of the CALL statement: "
430  CALL $FB00,A$,"is ",B$,C$,STR$(12)   ' Call the assembly routine
440  PRINT A$
450  CALL $FB00,B$,J                ' This line should cause an error
```

This calls the assembly language routine with several string arguments. It produces the following output when run:

```
This is a test of the CALL statement: 12.00000

450  String Variable Error
```

D.3.3 SYSTEM Example

The example uses an assembly language routine that counts the number of bits that are set in a 16 bit word. In the word $FFFE (1111111111111110, in binary), for example, there are 15 bits set. The BASIC program passes the word argument in the HL register using the SYSTEM statement. The assembly routine looks like this:

```
      XOR   A                 ; Clear the bit count
      LD    B,16              ; Set up loop counter

LOOP: RR    H
      RR    L                 ; Rotate least significant bit into carry flag
      JR    NC,LEND           ; Jump if bit is 0
      INC   A
LEND: DJNZ  LOOP              ; Do all 16 bits
      LD    H,0
      LD    L,A               ; Return result in HL
      RET
```

This program is assembled and put into a Bear BASIC program to be tested:

```
100  INTEGER J,K,ARG(3)
200  DATA $AF,$06,$10,$CB,$1C,$CB,$1D,$30,$01,$3C,$10,$F7,$26,$00,$6F,$C9
290  DATA -1
300  J=$FB00                        ' Load the assembly routine at $FB00
310  READ K
320  IF K=-1 THEN 400
330  POKE J,K
340  J=J+1
350  GOTO 310
400  ARG(3)=$FFFE
410  SYSTEM $FB00,ARG(0)
420  PRINT ARG(3)
```

When this program is run, it prints 15 as the result, just as expected.

Appendix E
Hardware Installation Recommendations

Because of its small size and use of plug-in connectors, the Boss Bear is easily mounted in a standard industrial enclosure. The figures in this appendix provide the mounting dimensions for all versions of the Boss Bear.

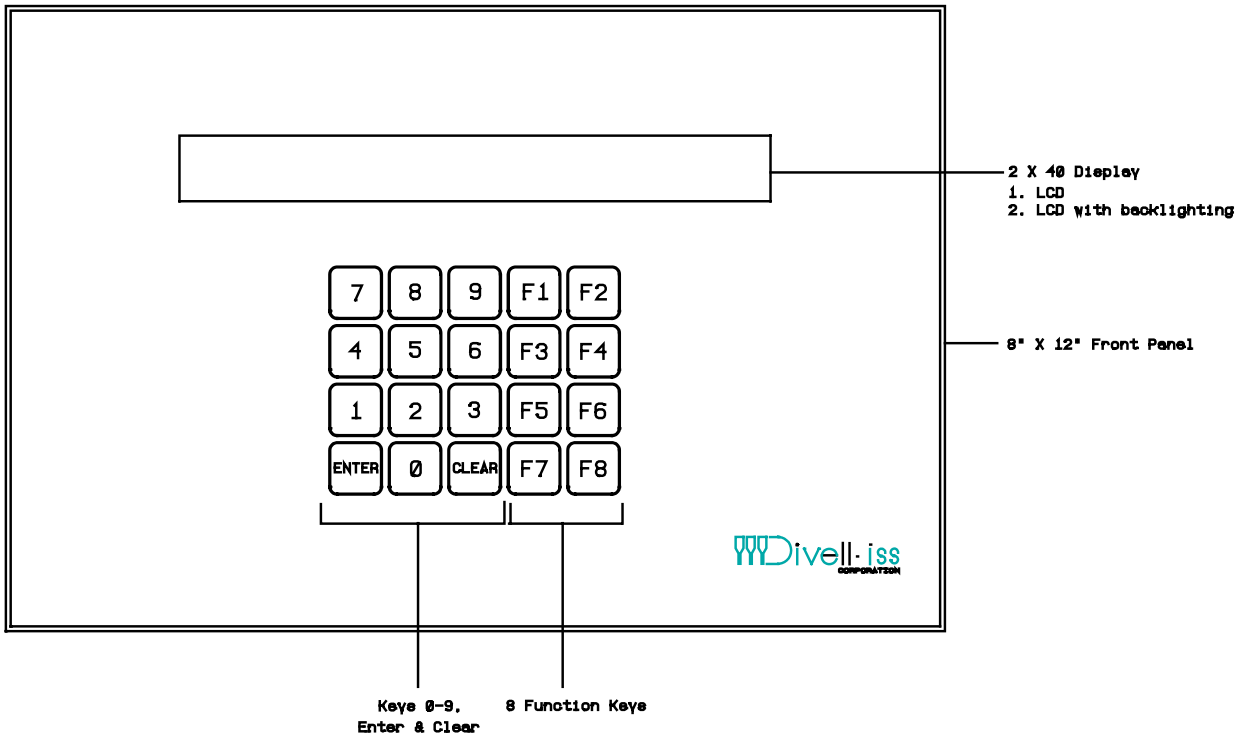


Figure 30 – Boss Bear, LCD or Backlight LCD Version

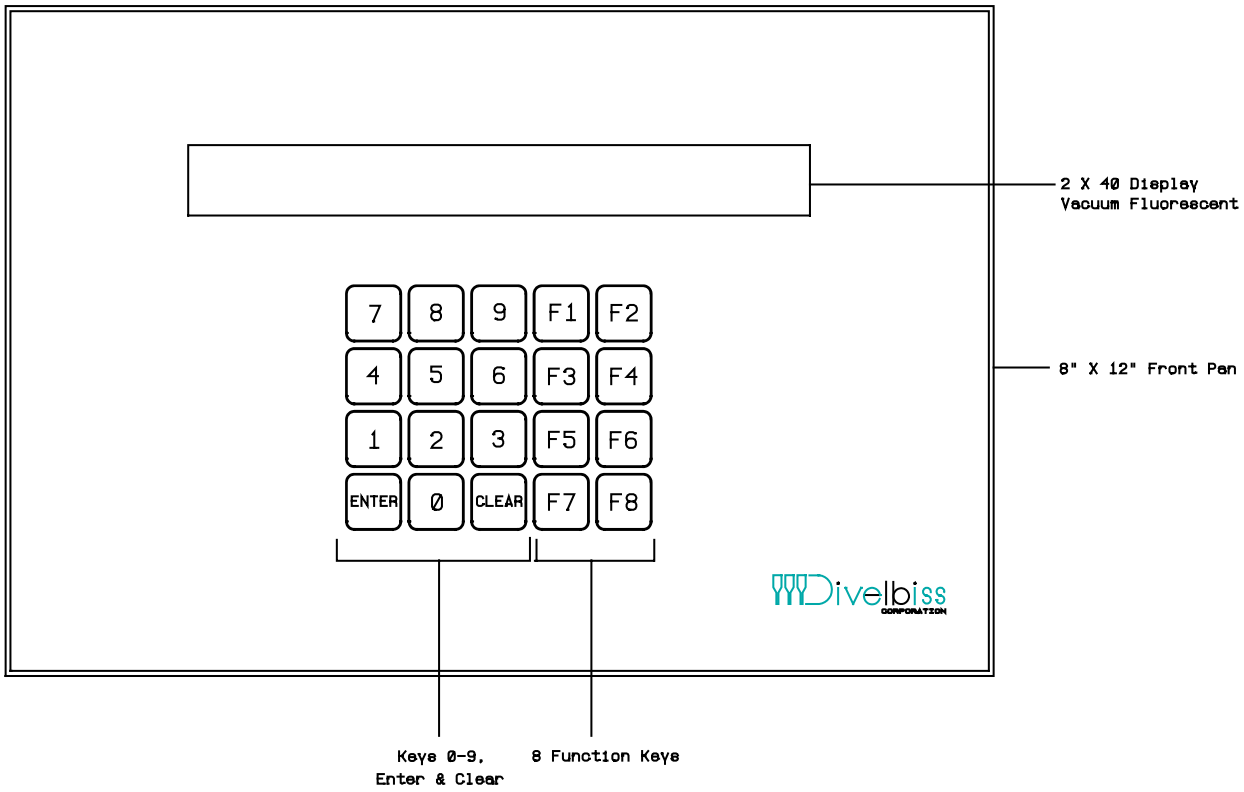


Figure 31 – Boss Bear, Vacuum Fluorescent Display Version

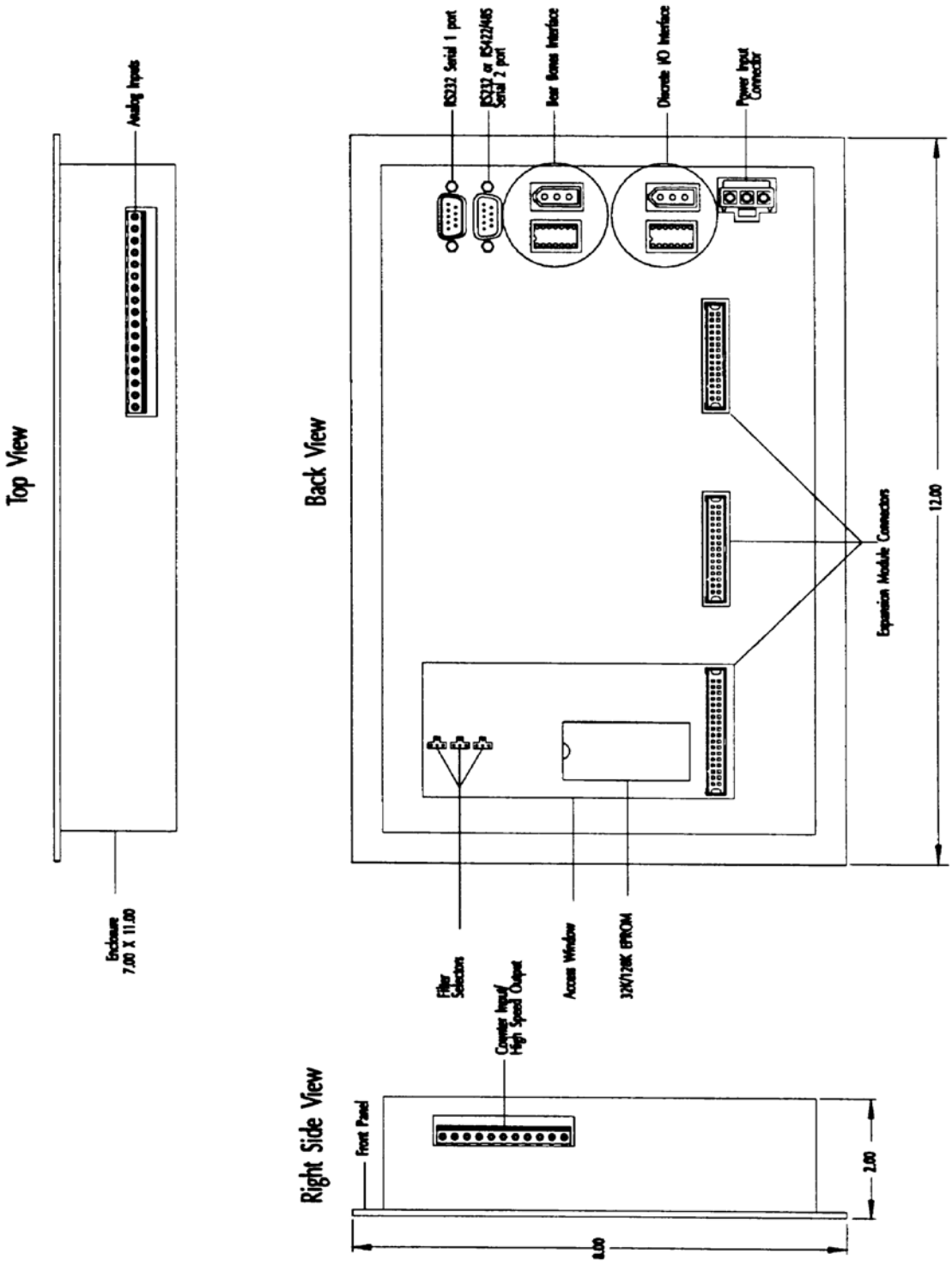


Figure 32 – Boss Bear Back Panel Detail

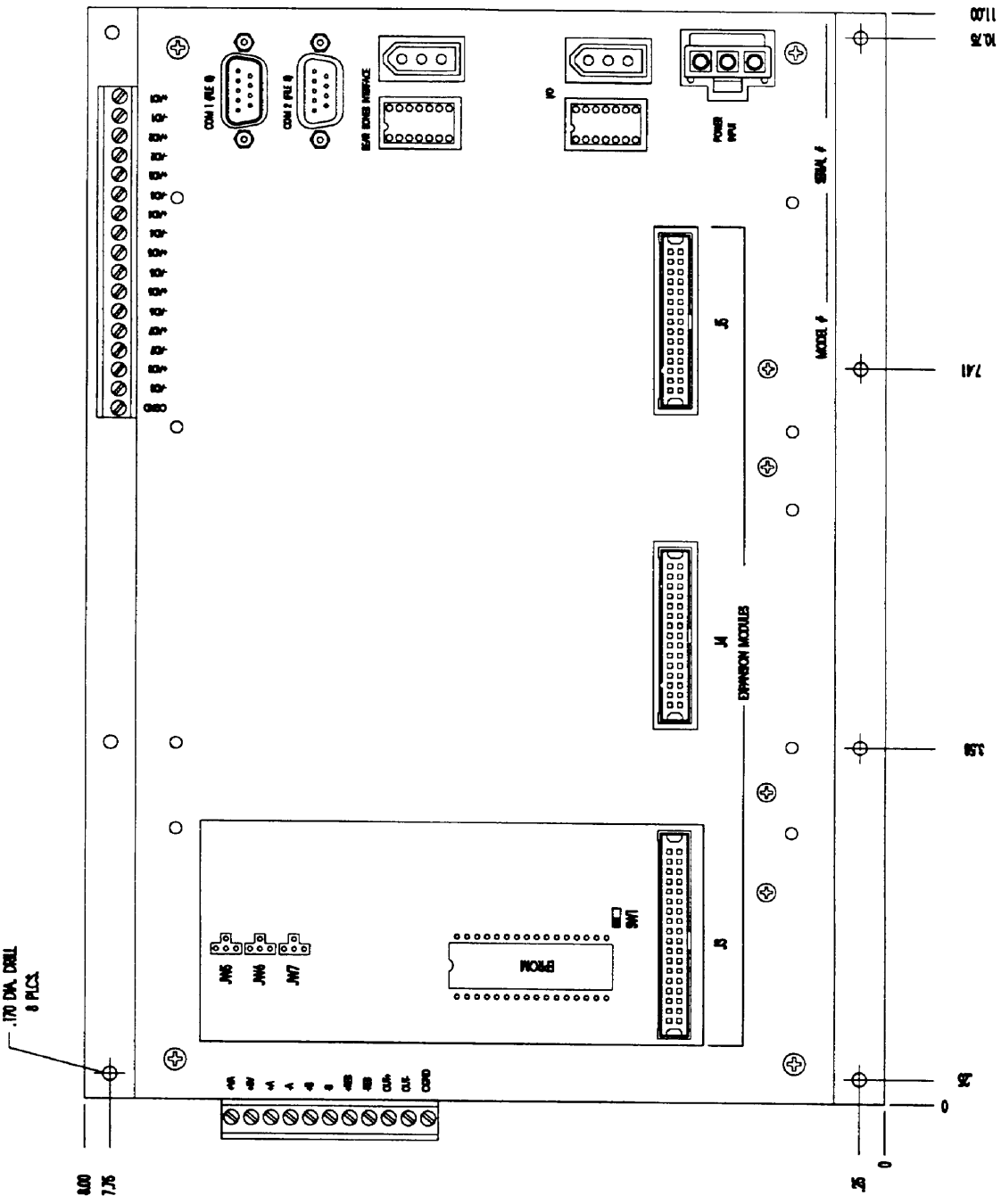


Figure 33 – Panel Dimensions for Plain Unit

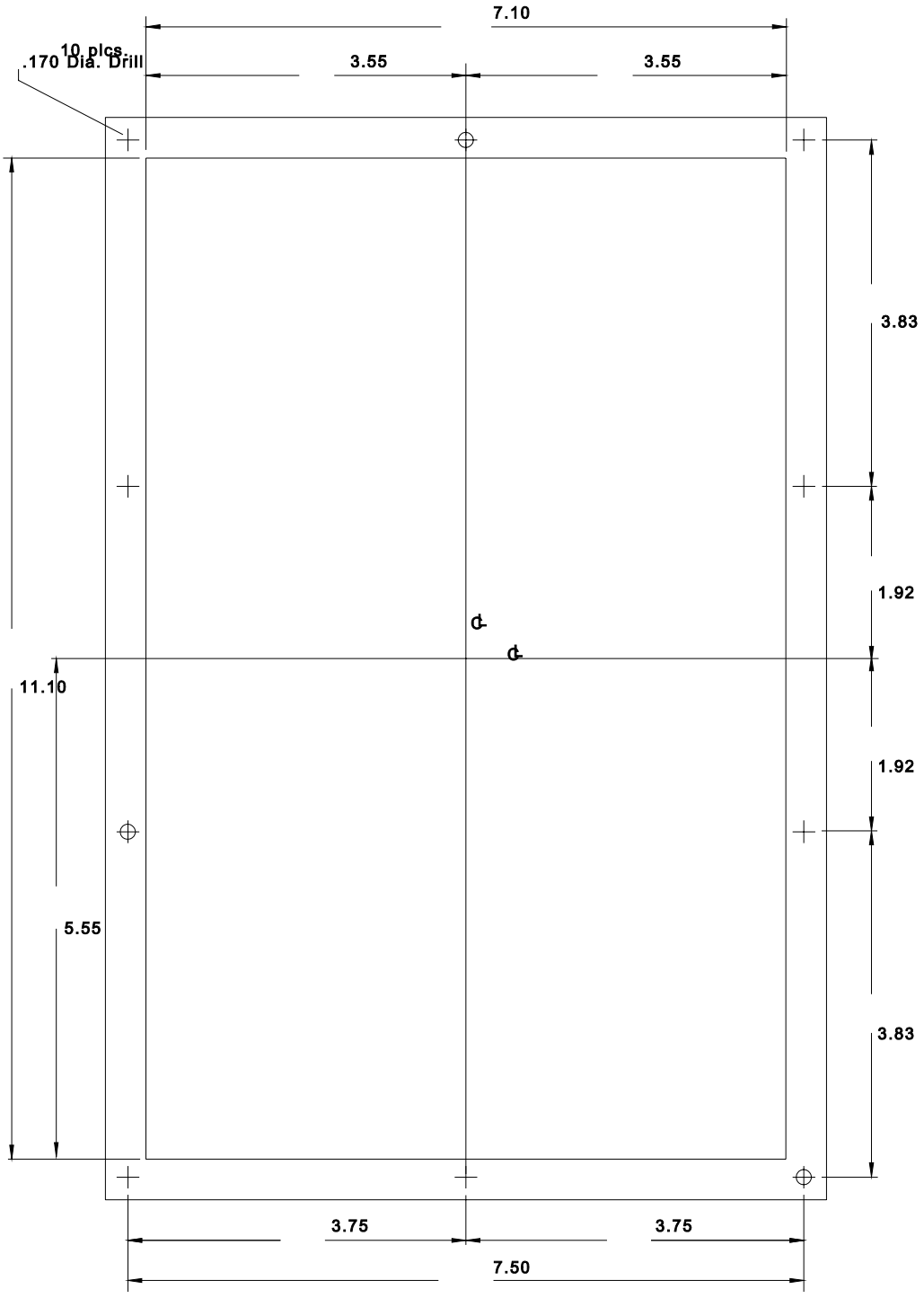


Figure 34 – Panel Cutout Template

Appendix F
ASCII Character Table

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	00	NUL	32	20		64	40	@	96	60	`
1	01	SOH	33	21	!	65	41	A	97	61	a
2	02	STX	34	22	"	66	42	B	98	62	b
3	03	ETX	35	23	#	67	43	C	99	63	c
4	04	EOT	36	24	$	68	44	D	100	64	d
5	05	ENQ	37	25	%	69	45	E	101	65	e
6	06	ACK	38	26	&	70	46	F	102	66	f
7	07	BEL	39	27	'	71	47	G	103	67	g
8	08	BS	40	28	(	72	48	H	104	68	h
9	09	HT	41	29	)	73	49	I	105	69	i
10	0A	LF	42	2A	*	74	4A	J	106	6A	j
11	0B	VT	43	2B	+	75	4B	K	107	6B	k
12	0C	FF	44	2C	,	76	4C	L	108	6C	l
13	0D	CR	45	2D	-	77	4D	M	109	6D	m
14	0E	SO	46	2E	.	78	4E	N	110	6E	n
15	0F	SI	47	2F	/	79	4F	O	111	6F	o
16	10	DLE	48	30	0	80	50	P	112	70	p
17	11	DC1	49	31	1	81	51	Q	113	71	q
18	12	DC2	50	32	2	82	52	R	114	72	r
19	13	DC3	51	33	3	83	53	S	115	73	s
20	14	DC4	52	34	4	84	54	T	116	74	t
21	15	NAK	53	35	5	85	55	U	117	75	u
22	16	SYN	54	36	6	86	56	V	118	76	v
23	17	ETB	55	37	7	87	57	W	119	77	w
24	18	CAN	56	38	8	88	58	X	120	78	x
25	19	EM	57	39	9	89	59	Y	121	79	y
26	1A	SUB	58	3A	:	90	5A	Z	122	7A	z
27	1B	ESC	59	3B	;	91	5B	[	123	7B	{
28	1C	FS	60	3C	<	92	5C	\	124	7C	|
29	1D	GS	61	3D	=	93	5D	]	125	7D	}
30	1E	RS	62	3E	>	94	5E	^	126	7E	~
31	1F	US	63	3F	?	95	5F	_	127	7F	DEL

ASCII, which is an acronym for American Standard Code for Information Interchange, is one of the main ways in which computers process text data. Each printable character is represented as a number between 32 and 126 ($20 and $7E). The numbers between 0 and 31 ($00 and $1F) form the "control codes", such as carriage return ("CR"), backspace ("BS"), and horizontal tab ("HT").

Appendix G
Bear BASIC Release History

Divelbiss is constantly improving and extending the Boss Bear and Bear Bones product lines. New versions of the Bear BASIC compiler are periodically released in order to support new expansion modules, add new features, and fix software bugs. The following lists show the enhancements at each software release.

Some Bear BASIC updates affect the operation of the Boss Bear in ways that may require changes in the user's BASIC source code. Most existing programs should run without modifications. Programs which contain critical timing that has been "tuned" to work with the previous software will probably require modification, since the compiler generates slightly different code with each new release.

Note: In order to run existing programs with new firmware, the programs must be recompiled. If an EPROM containing code that was compiled with a previous version is installed, the message PROM is incompatible with this Compiler Version will be displayed. Simply load the original source code for the program, recompile it, and save the compiled code onto a blank EPROM

Version 1.00

Version 1.00 was released in September, 1989. It was the first release of the Bear BASIC compiler.

Version 1.02

Version 1.02 was released in January, 1990. It was the first stable release of the Bear BASIC compiler.

Version 2.01 Additions and Modifications

Version 2.01 was released on May 9, 1991.

- It now swaps tasks while waiting for INPUT and GET statements. This improves system performance.

- It now continues multitasking while file 0 and file 5 outputs are XOFFed. It used to stop multitasking while waiting for an XON to be received, giving the appearance that the system had locked up.

- Support for windowing has been removed, in order to provide more room for the user's program. The window statements were not useful in most control applications, and they are easily emulated using BASIC subroutines.

- ERASE and CLS now support the LCD and VFD.

- GOTOXY and LOCATE now support file 0 and file 5.

- Previously, there was a bug in which programs that had more than 16 tasks would do strange things while accessing strings. This has been fixed.

- The context switcher now operates slightly faster, resulting in more processor time available for running the user's program.

- The multiply routine is now about 3 to 12 times faster than it was. This speed increase is evident with the '*' operator, as well as with array indexing.

- Previously, there was a bug in the context switcher that would cause the system to lock up when the WAIT statement was used. Generally, it only happened with long WAIT times (greater than 20 seconds). This has been fixed.

- Previously, the resource locking portion of the context switcher had a few bugs; these generally showed up while PRINTing from multiple tasks at the same time. For example, the following simple program should alternately print groups of about ten 0's followed by about ten 1's, but with the v1.02 compiler it would print lots of 0's followed by lots of 1's.

```
100  RUN 1
110  PRINT "0"; : GOTO 110
200  TASK 1
210  PRINT "1"; : GOTO 210
```

- Previously, the CANCEL statement didn't work exactly as stated in the manual. The manual says that CANCEL doesn't immediately stop an executing task, only that it keeps a task from being rescheduled. Actually, in v1.02 CANCEL could stop the task at a random point in time (generally, the next time that the context switcher looked at that task); this is the way a lot of people thought that CANCEL should work, but it can cause strange things to happen in a program. It has been changed to match the description in the manual, which causes the operation of a program using CANCEL to be more consistent.

- The keypad auto-repeat rate is now about twice as fast as it used to be. Several people complained that the old one was too slow.

- The keypad scan rate has been slowed to support remotely located keyboards.

- The method by which constants are compiled has been changed, resulting in smaller compiled code.

- New optimization algorithms have been added to the compiler, resulting in smaller compiled code and slightly faster operation.

- There is more space available for storing the user's source code.

- There is more space available for storing the compiled code.

- The CHAIN command has been added; it works with both integer (file number) and string (file name) arguments.

- The INTERRUPT statement has been added, in order to make it easier to utilize the high speed counter as an interrupt source. As new expansion modules are added, INTERRUPT will be modified to support them.

- RDCNTR, WRCNTR, and CNTRMODE now support the high speed counter expansion modules.

- The DAC statement supports the Digital to Analog (DAC) expansion modules.

- The ADC function supports the 12 bit Analog to Digital (ADC) expansion modules; it also automatically detects and supports the onboard 12 bit ADC and onboard 10 bit ADC.

- The NETWORK statement has been added to provide a link into the Bear Direct factory communications network.

- Previously, if MID$ was called with a 0 length argument, the system would lock up. This has been fixed.

- Previously, the compiler did not detect when it had run out of memory. It now displays the error Not Enough Memory to Compile Program when the program gets too large. If there has been too much variable space allocated, then it will give this error on the first code-generating line of the program; in this case, STAT gives erroneous numbers.

- Previously, the variables were stored in different locations depending upon the number of tasks in the program. This meant that variables couldn't be passed between programs when chaining, unless both programs had the same number of tasks. This has been changed so that CHAIN works regardless of the number of tasks in the programs; variables can always be passed.

- Removed the INTMODE statement, which was unnecessary because of the Boss Bear hardware design.

- Added resource locking for EEPOKE/EEPEEK, to allow them to be used in multiple tasks at the same time. Previously, if a task tried to EEPEEK while another task was EEPOKEing, it would read an incorrect value.

- The HELP direct command was added, providing online help screens.

- New "Un" option for FPRINT provides the ability to display an integer as an unsigned value.

- New FINPUT statement allows easier user input of numeric values.

- DIR direct command to display contents of user's EPROM and amount of free space on EPROM.

- DOWNLOAD direct command disables echo to provide better error display during program download. This also speeds up the download operation on long files.

- L now works correctly as the short form for the LIST direct command.

- A bug in RDCNTR has been fixed. Previously, if RDCNTR was called with a REAL variable, the value $800000, when converted to a real number, would cause the system to lock up.

- The ERR function and ON ERR statement have been implemented to allow a program to detect and handle serial communication errors and EEPROM programming failures without halting the program.

- Address $0013 is the vector for the error processor, so that a BASIC program can trap fatal errors using JVECTOR. This allows the program to halt the system gracefully and restart the program or CHAIN to another program.

- A program line can begin with a direct command string, without being treated as a direct command. For example the line `CLS: X=0` can now be entered without requiring a line number; `CLS` by itself would still require a line number, however.

- The CNTRMODE statement now allows the LATCH input to enable and disable the counter.

- The user's manual has been totally rewritten; the new manual is much more accurate than the previous manual.

Version 2.01 Anomalies

- The contrast adjustment on the LCD versions doesn't work correctly while a program is running. This happens when a program writes to the LCD very often; there isn't enough time between LCD operations to allow the contrast adjustment to take place. The solution is to write to the LCD less often.

- CEXPR handles combined REAL and INTEGER expressions incorrectly. If the overall result is INTEGER, it will convert the partial result to INTEGER before it really should.

```
INTEGER J,K
REAL X,Y,Z
```

```
X=6144000: Y=20
Z=(X / Y) / 10.0              ' This returns 31220.0
J=X / Y / 10.0                ' This returns 31220
J=(X / Y) / 10.0              ' This returns -2048
```

This problem is described in the original manual, and is well documented in the new manual; at this point, it will probably never be changed.

- The statement EEPOKE J,WPEEK(ADR(M(K))) doesn't store anything at EEPROM location J. If this is broken into two parts, however, it seems to work fine:

```
X=WPEEK(ADR(M(K))): EEPOKE J,X
```

- When saving to the EPROM, the "Duplicate line numbers detected" error is printed sometimes. The code is saved successfully, however.

- User defined functions don't handle strings correctly, under some conditions. Avoid using string operations in user defined functions.

- The CHAIN operation does not clear the source code area, so when using CHAIN, the source code may not reflect the object code that is in memory. For example, assume that the source code for program "A" is loaded, compiled, and run; program "A" chains to program "B", which then STOPs. The source code for program "A" will still be loaded, but if the programmer types GO (without COMPILE), then program "B" will be executed, since it is the most recently loaded compiled program.

- Problem with LOCATE and GOTOXY when using the console. If multiple tasks try to perform LOCATE/GOTOXY and print operations, the screen becomes garbled, because one task could corrupt another task's terminal control codes.

- A PRINT statement followed by many array references causes the compiler to lock up while compiling the line.

- When the line `INTEGER J: FINPUT "F3.2",J` is executed, a problem occurs if a number starting with a decimal point (ie. ".34") is entered. The system prints the "*** Bad input, please re-enter ***" message.

- It accepts a line numbered 0, but the compiler doesn't handle it correctly.

- The compiler disables interrupts while converting a real number to a string; this occurs when printing a real number or executing STR$(). This leaves the interrupts turned off for several msec, which can cause incoming serial data to be lost.

- The ADC function uses channels 1 through 12 for the onboard 10 bit A/D, and channels 1 through 8 for the onboard 12 bit A/D. Both should use channels 1 through 12, in order to ensure consistent operation of user's programs.

Version 2.02 Additions and Modifications

Version 2.02 was released on May 5, 1992.

- The NETMSG statement was added, along with low level support of network messages.

- Fixed problem with LOCATE and GOTOXY when using the console. Previously, if multiple tasks tried to perform LOCATE/GOTOXY and print operations, the screen would become garbled because a task could corrupt another task's terminal control codes. This will still allow things to be printed at the "wrong" locations, but at least the escape codes don't get garbled.

- A PRINT statement followed by many array references would cause the compiler to lock up while compiling the line. Now this will print the error message "Statement too Complex".

- When the line INTEGER J: FINPUT "F3.2",J was executed, a problem occurred if a number starting with a decimal point (ie. ".34") is entered. The system would print the "*** Bad input, please re-enter ***" message. This has been fixed.

- It would accept a line numbered 0, but the compiler didn't handle it correctly. The parser has been changed to give an error if line 0 is entered.

- Interrupts are now left enabled while converting a real number to a string.

- The SETOPTION DAC direct command was added, to allow the DAC channels to be initialized at reset.

- The ADC function uses channels 1 through 12 for both the onboard 10 bit A/D and the onboard 12 bit A/D.

Version 2.03 Additions and Modifications

Version 2.03 was released on July 14, 1992.

- The network handler now supports more network registers. There is now about 20K of space available for storing network registers, which allows up to 10000 integer registers, 5000 real registers, or 485 string registers. This is useful for downloading "recipes" using Lotus 123 and @FACTORY, by making a huge spreadsheet containing all of the configuration data and sending it with @WRITE functions.

- The SETOPTION DAC direct command was modified so that it only initializes the DAC on power-up, not when a BASIC program stops or when chaining between programs.

Version 2.03 Anomalies

- The contrast adjustment on the LCD versions doesn't work correctly while a program is running. This happens when a program writes to the LCD very often; there isn't enough time between LCD operations to allow the contrast adjustment to take place. The solution is to write to the LCD less often.

- The statement EEPOKE J,WPEEK(ADR(M(K))) doesn't store anything at EEPROM location J. If this is broken into two parts, however, it seems to work fine:

```
X=WPEEK(ADR(M(K))): EEPOKE J,X
```

- When saving to the EPROM, the "Duplicate line numbers detected" error is printed sometimes. The code is saved successfully, however.

- User defined functions don't handle strings correctly, under some conditions. Avoid using string operations in user defined functions.

- The CHAIN operation does not clear the source code area, so when using CHAIN, the source code may not reflect the object code that is in memory. For example, assume that the source code for program "A" is loaded, compiled, and run; program "A" chains to program "B", which then STOPs. The source code for program "A" will still be loaded, but if the programmer types GO (without COMPILE), then program "B" will be executed, since it is the most recently loaded compiled program.

Version 2.04 Additions and Modifications

Version 2.04 was released on October 12, 1992.

- The system has been modified so that the BASIC source code is stored more efficiently, allowing the user's source program to be about 2000 characters longer.

- The EXMOD statement was added to provide access to the intelligent expander modules.

- Previously, the PRINT statement could not output a 0 byte (i.e. CHR$(0)) over the serial ports. This has been corrected.

Version 2.04 Anomalies

Same as V2.03 anomalies, listed above.

Version 2.06 Additions and Modifications

Version 2.05 was only released for beta testing.
Version 2.06 was released on November 2, 1992.

- A flag byte was added at location $A9 to enable and disable XON/XOFF and control-C checking on file 0. Bit 0 is set to enable XON/XOFF and cleared to disable it. Bit 1 is set to enable control-C checking and cleared to disable it. The default flag value is 3, causing both XON/XOFF and control-C checking to be enabled.

Version 2.06 Anomalies

Same as V2.03 anomalies, listed above.

Version 2.07 Additions and Modifications

Version 2.07 was released on March 10, 1993

- A problem was corrected in which the Boss Bear software didn't correctly identify the optional onboard 12 bit A/D chip under some conditions.

Version 2.07 Anomalies

Same as V2.03 anomalies, listed above.

Version 2.08 Additions and Modifications

Version 2.08 was released on March 30, 1993

- A problem was corrected in which some Boss Bears would lock up when the INTERRUPT statement was used with a counter module plugged into J4 or J5.

Version 2.08 Anomalies

Same as V2.03 anomalies, listed above.

Version 2.09 Additions and Modifications

Version 2.09 was released on December 10, 1993

- When two (or more) tasks were performing string operations, and one of the tasks was set to a nonzero priority, it was previously possible for the Boss Bear to enter a deadlocked state, preventing it from executing the user's program. Version 2.09 corrects this problem.

Version 2.09 Anomalies

Same as V2.03 anomalies, listed above.

Version 2.10 Additions and Modifications

Version 2.10 was released on October 31, 1994

- The SERIALDIR statement was added to the Boss Bear to match the UCP.

- A problem was corrected in which the network peer to peer transfers were not being transferred correctly and world overwrite the basic listing.

- Comments using the ! will now be deleted in the basic listing. This allows the user to download a program into the Boss Bear having comments with the ! and not take up source code space. Comments using the REM or ‘ will function the same as before.

- The EXPMEM statement was added to the UCP to use the expanded memory board option on the. This board and statement allows the user to have an added 512K of data storage space. Note that this does not expand the program space.

- The HELP text has been expanded to include all the new commands added.

- The FUZZY statement has been added to the UCP in the optional version, 2.10f. This is a fuzzy logic control statement to be used for a verity of control applications.

- The NETSERVER statement has been added to the UCP. This allows the UCP to arbitrate a peer to peer network without the use of a computer and network card.

- A problem with the Boss Bear LCD contrast was encountered when the manufacture of the control IC changed the device. This problem has been fixed with this release.

Version 2.10 Anomalies

Same as V2.03 anomalies, listed above.

Appendix H
Universal Control Panel

This appendix describes the differences between the Boss Bear and the Universal Control Panel (UCP). When working with the UCP, any questions should be answered by turning here first, and then referring back to the main portion of the manual if the topic isn't covered here. The information in this appendix supercedes the rest of the manual when using the UCP.

H.1 High Speed Counter

Counting is a very common operation in real time control systems. For low speed signals (less than 10 pulses/second), this can be handled easily in software. At higher rates, however, hardware counters are required. The UCP high speed counter circuit is very flexible, providing several operating modes. It is a 24 bit binary up/down counter, capable of greater than 1 MHz count rate (333 kHz in quadrature modes), with a high speed output. It supports quadrature mode, which allows it to operate with biphase shaft encoders. In order to understand the operation of the counter, it is helpful to look at the hardware logic.

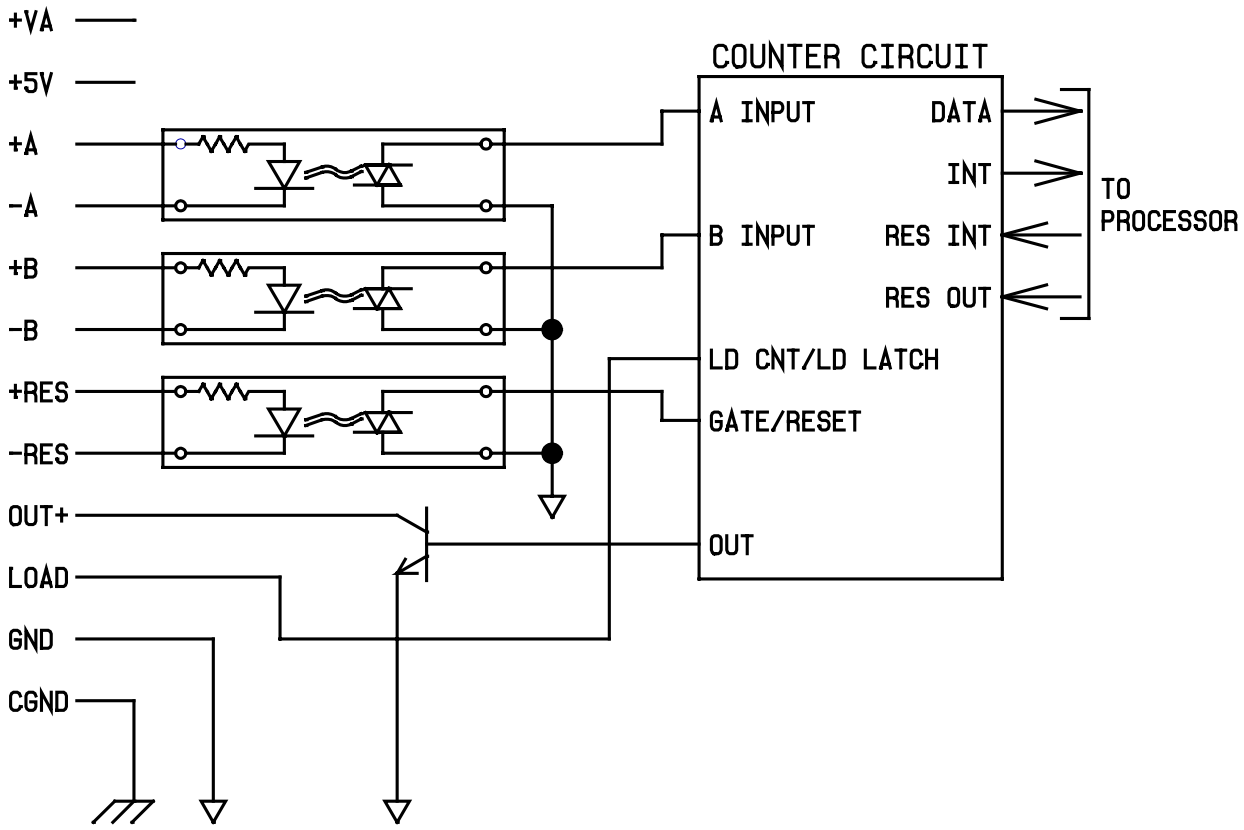


Figure 35 – High Speed Counter Logic

The **A**, **B**, and **RES** inputs can be used with either open-collector or differential outputs. The **A** and **B** inputs are the signals to be counted; they are edge triggered. The counter can operate in four input modes:

1. The **A** and **B** inputs are used in quadrature X1 mode, for use with biphase encoders.Thecountvaluechanges once for each biphase cycle.

2. The **A** and **B** inputs are used in quadrature X4 mode, for use with biphase encoders. The count value changes with each input transition; X4 mode counts four times faster than X1 mode, given the same input signal.

3. A falling edge on the **A** input (while the **B** input is high) causes the counter to increment, and a falling edge on the **B** input (while the **A** input is high) causes the counter to decrement. Inputs **A** and **B** should not be high at the same time.

4. The **B** input sets the count direction: high for increment, low for decrement. A falling edge on the **A** input causes the counter to count in the selected direction.

If the counter is to be used in unidirectional mode, it should be put into mode 4. The count signal would be connected to the **A** input, and the **B** input would control the direction.

The **RES** input can be used to reset the counter. **RES** is active high. A pulse on **RES** will cause the counter hold its current value (disregarding **A** and **B**) or reset to 0, depending upon the software configuration of the circuit.

A pulse on **LOAD** will cause the counter value to be preset from the input latch or written to the output latch, depending upon the software configuration of the circuit. Both **RES** and **LOAD** are seperate inputs allowing full access to the counter control signals. In this configuration, a single input signal can be wired to latch the current counter value into the output latch, and then reset the counter value to 0.

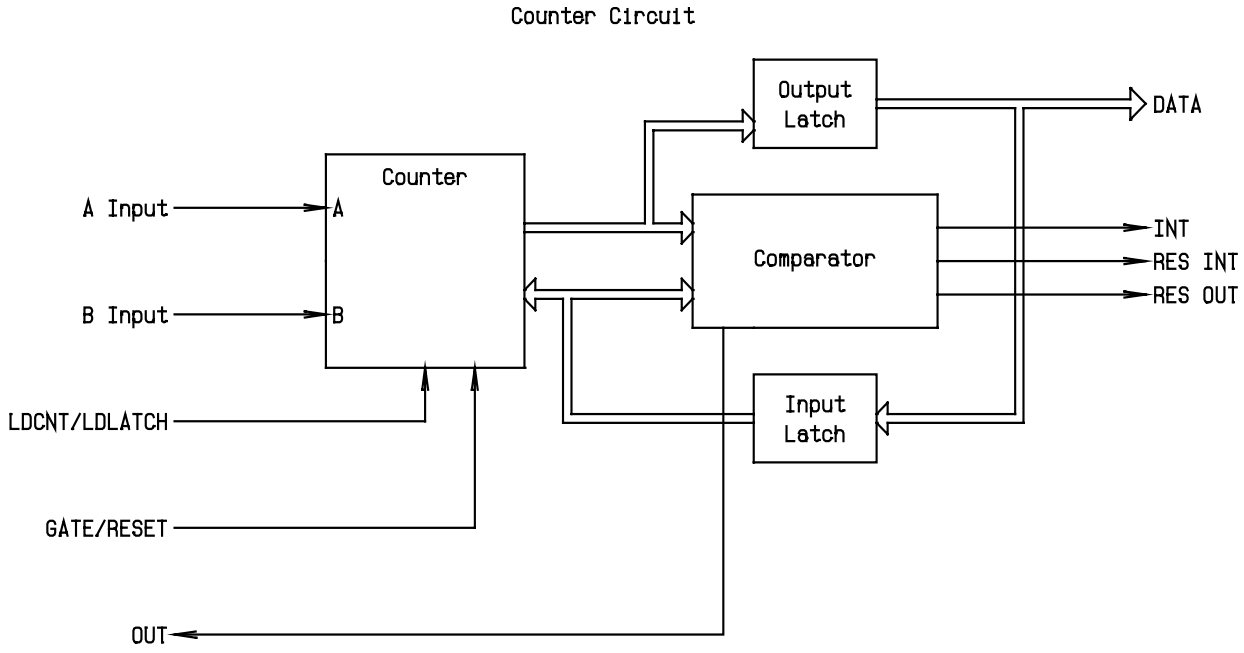


Figure 36 – Internal Counter Logic

When the counter value matches the value stored in the input latch, the comparitor will assert the high speed output and also send an interrupt signal to the processor. These signals stay active until the processor resets each of them with the appropriate control line (RES_OUT and RES_INT). RDCNTR can reset the high speed output. The output circuit is open-collector; Figure 37 shows two ways to use the output.

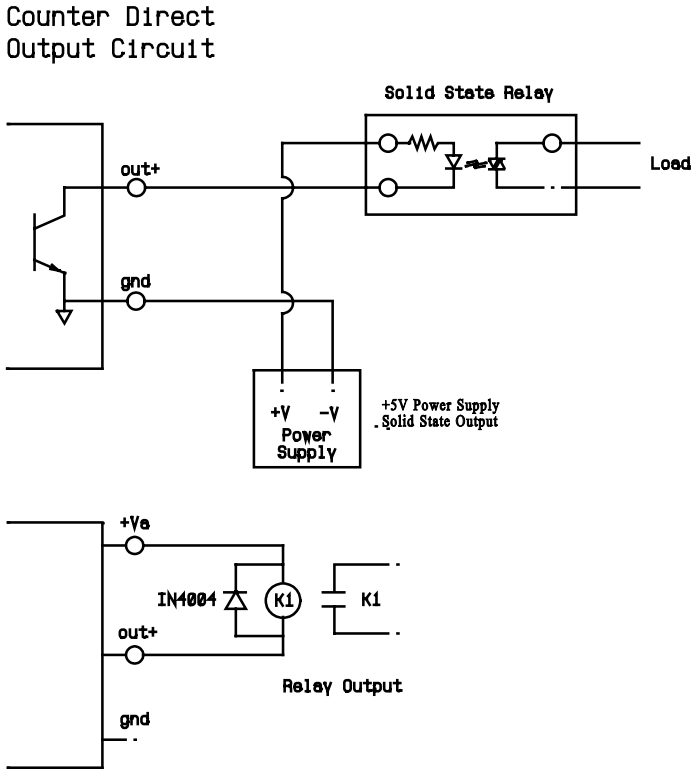


Figure 37 – Using the Counter Direct Output

The counter inputs **A**, **B**, and **RES** are designed to be used with differential sensor outputs. Contact Divelbiss for encoder recommendations. Figure 38 shows an example of wiring a biphase incremental encoder to the UCP.

For best noise immunity, shielded cable should be used between the counter inputs and the device being monitored; this is especially important for long cable runs. To minimize any potential crosstalk problems, it is recommended that individually paired and shielded cables be used for each I/O device, especially at high counting speeds. Use the shield terminal provided or connect the shield to earth ground by other means. Do not connect the cable shield at both ends of the cable, as this can have an adverse effect. Always use separate returns (minus terminal) for each signal pair, as this lessens the chance of ground loops occurring by making all common terminations at the counter module.

H.1.1 Counter Examples

The simplest example of using the counter just reads the current count value and displays it on the onboard display. To try this example, just wire a pushbutton between **+5V** and **+A**,

then connect the **-A** input to **GND**. Each time that the button is pushed, the counter will increment one or more times; the button will probably bounce when pressed, causing up to 20 pulses.

```
100  INTEGER COUNT
110  CNTRMODE 1,3                          ' A counts up, B counts down
120  WRCNTR 1,0,10                         ' Set counter value to 10
130  FILE 6
140  RDCNTR 1,0,COUNT                      ' Read the current value
150  FPRINT "U6Z",COUNT                    ' Now display it
160  GOTO 140
```

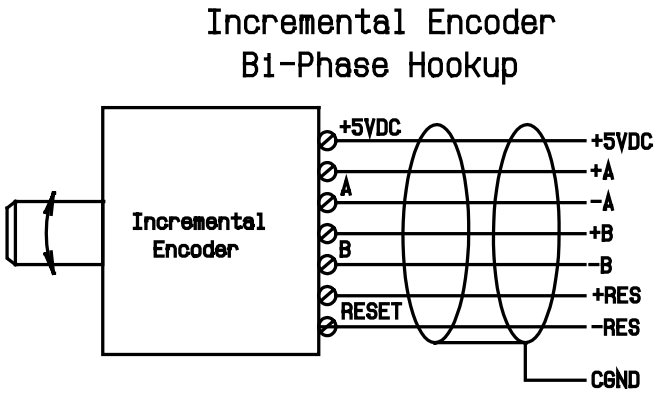


Figure 38 – Biphase Incremental Encoder Wiring Example

The next example shows how to handle counter interrupts and use the high speed output. This example sets up task 1 as the interrupt handler for counter 1. In lines 120 and 130 it initializes counter 1, setting its mode to A-count, B-direction and writing a 0 to the counter. In lines 140 and 150 it sets the counter reload variable to 10 and writes this reload value into the counter's compare register. Line 160 uses INTERRUPT to set task 1 as the interrupt handler for the counter. Lines 210 to 240 form the program's main loop, which just displays the latest counter value (COUNT) from the last interrupt; it also increments and displays J, just to cause some action on the display. Lines 300 to 350 form task 1, the interrupt handler; it reads the current counter value and updates the reload value. Lines 400 to 440 form task 2, which turns off the high speed output about 1/2 second after it is turned on.

In task 1, the first thing that it does is read the current counter value. At low pulse rates, this will be the same as RELOAD, since it is reading the same value that caused the interrupt. As the pulse rate increases, however, the counter will increment before the task 1 gets to read the counter. At a very high pulse rate, a problem will occur when the counter has already gone beyond the new RELOAD value before RELOAD is written to the counter (ie. COUNT=783 and RELOAD=780); this effectively stops the interrupt, since the counter will need to wrap completely around before the interrupt will occur again.

```
100  ' Program to demonstrate the high speed counter interrupt
110  INTEGER J, RELOAD, COUNT, T2TEMP
120  CNTRMODE 1,4                          ' A count, B direction
130  WRCNTR 1,0,0                          ' Set count to 0
140  RELOAD=10: COUNT=0
150  WRCNTR 1,1,RELOAD                     'Set counter interrupt value
160  INTERRUPT 1,1,1                       ' Set counter interrupt to task 1
170  J=0
```

```
180  FILE 6                                ' Output to onboard display
200  ' Main program loop.
210  LOCATE 1,1
220  FPRINT "U5X5U5Z", J, COUNT
230  J=J+1                                 ' Increment junk variable
240  GOTO 210
300  ' Counter interrupt handler task.
310  TASK 1
320  RDCNTR 1,0,COUNT                      ' Get new count
330  RELOAD=RELOAD+10                      ' Set up new reload
340  WRCNTR 1,1,RELOAD                     ' Set counter interrupt value
350  RUN 2: EXIT                           ' Set up task 2 to turn output off.
400  ' Task to turn off high speed output
410  TASK 2
420  WAIT 50                               ' Wait 1/2 second, then turn
430  RDCNTR 1,3,T2TEMP                     ' the output off
440  CANCEL 2: EXIT                        ' Don't reschedule this task.
```

H.2 Analog Interface

H.2.1 0-5VDC Analog I/O Board

The optional A/D converter has 8 differential, 12 bit, 0 to 5 VDC input channels. It is read using the ADC function, which scales the A/D output to return a value between 0 (at 0 VDC) and 32767 (at 5 VDC). Using the ADC function, the A/D conversion time is approximately 350 microseconds. The onboard A/D provides 12 bit resolution, or about 0.025% accuracy.

The A/D input voltage is not limited, but is buffered, to protect the A/D converter. If an input goes above 5 VDC, the A/D will not read correctly. Therefore, the system should be designed so the input signal does not go above 5 VDC. All signal cables should be shielded running to the sensor; the shield should be attached to chassis ground (**CGND** on the A/D terminal strip) at the UCP end only.

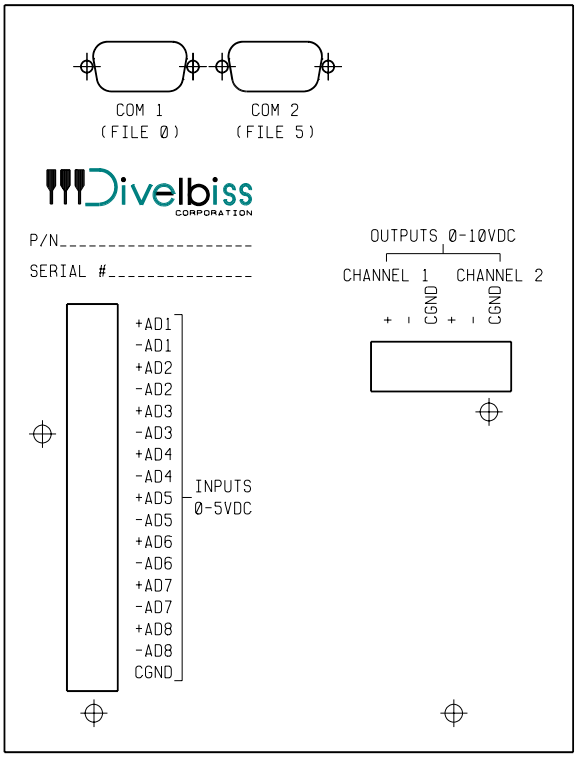


Figure 39 – 0-5V Analog I/O Board Back Panel Detail

When the 12 bit onboard A/D option is installed, it supplies the first 8 A/D channels (when read with the ADC() function), as follows:

Channel	Description
1	AD1
2	AD2
3	AD3
4	AD4
5	AD5
6	AD6
7	AD7
8	AD8

The following example shows the use of the ADC function. It simply displays the voltage being read by the 8 A/D channels. In line 140, it reads the A/D value and converts it from A/D units (0 to 32767) to voltage (0.0 to 5.0).

```
100  ' Display the first 8 A/D channels
110  INTEGER CHAN
120  REAL ADVAL
130  FOR CHAN = 1 TO 8
140    ADVAL = ADC(CHAN)/32767.0*5.0
150    PRINT "Channel "; CHAN; " = "; ADVAL
160  NEXT CHAN
```

It is often necessary to convert an A/D reading into the appropriate engineering units, either for display purposes or to make the program easier to understand. In the previous example, the number was displayed as a voltage. In general the following formula performs the necessary scaling:

$$\frac{Reading}{32767} * (Maxval - Minval) + Minval$$

where Reading is the A/D reading, Maxval is the maximum value that the sensor can measure, and Minval is the minimum value that the sensor can measure. For example if a temperature sensor returns 0 VDC at -50 degrees C and 5 VDC at 200 degrees C, then this formula becomes:

$$\frac{Reading}{32767} * (200 - (-50)) + (-50) = Reading * \frac{250}{32767} - 50$$

or, reduced to the simplest form and written as BASIC code: `CDEG=ADC(CH)*0.0076294-50.0`.

The following points must be observed to get the greatest accuracy from the UCP A/D converter:

- The UCP chassis ground (ground lead on the power input connector) must be attached to earth ground.
- The unused inputs on the A/D connector should be shorted (ie. ADn+ tied to ADn-).
- Shielded cable should be used to attach to the sensor. The shield should be attached to CGND at the UCP A/D connector. The other end of the shield should not be tied to ground, as this could cause a ground loop. Depending upon the construction and mounting of the sensor, the shield may or may not be attached to the sensor. If the sensor shield (which is probably its housing) is isolated from ground, then the shield should be attached to the sensor. If the sensor is attached to ground, then do not attach the shield, as this could cause a ground loop.
- The cable should be kept short, although it should be routed away from noise-producing equipment and power lines, if possible.
- The sensor should be chosen so that its output in the normal operating range is at the upper end of the UCP's A/D range. With the 12 bit, 0 to 5 VDC A/D, an input of 0.5 VDC results in 0.24% accuracy, while an input of 4.5 VDC results in 0.027% accuracy.

H.2.2 4 to 20mA Analog I/O Board

The optional A/D converter has 8 differential , 12 bit 4 to 20 mA input channels. The ADC function will return a value between 0 (at 4mA) and 32767 (@ 20mA). A/D conversion time is approximately 350μs. At 12 bit resolution the accuracy is about .025%. The input resistance is 309 ohms.

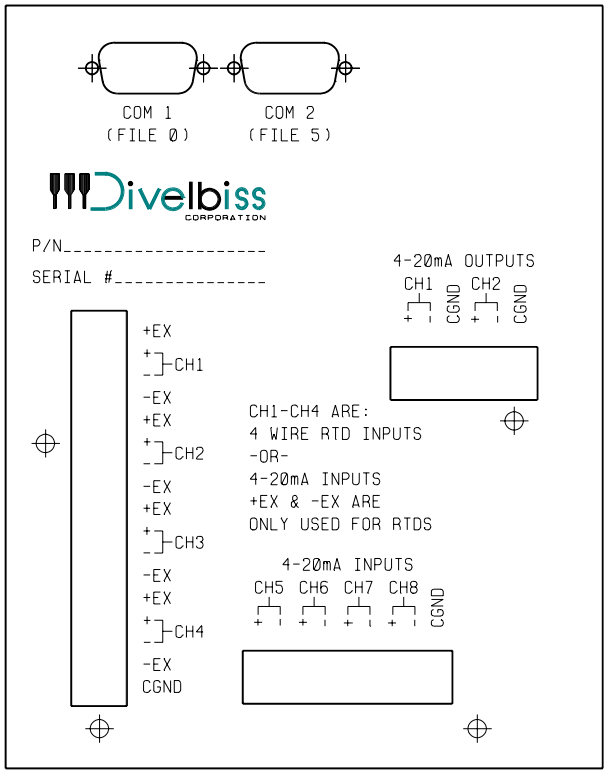


Figure 40 – RTD/4-20mA Analog I/O Board Back Panel Details

H.2.3 RTD and 4 to 20mA A/D Converter

On this optional A/D board are 4 channels of RTD inputs and 4 channels of 4 to 20mA inputs. The 4 to 20mA inputs are the same as covered in H.2.2. The RTD inputs are set up to use a 100 ohm 4 wire RTD. Linearization is a value between 0 (84.272 ohms) and 32767 (183.152 ohms). The resolution is .024 ohms.

Straight line formula used for 100 ohm .385 curve RTD. This formula is accurate to 2 degrees F in the range of 25 degrees F to 200 degrees F.

SUBROUTINE TO CONVERT deg F TO COUNTS

```
13000    TEMP = ESETPNT*71.26 + 3010.333
         SETPNT = TEMP
         RETURN
```

SUBROUTINE TO CONVERT COUNTS TO deg F

```
15000    TEMP = .014033*(A/D VALUE) - 42.24436
         RETURN
```

H.2.4 0-10VDC Digital to Analog Converter

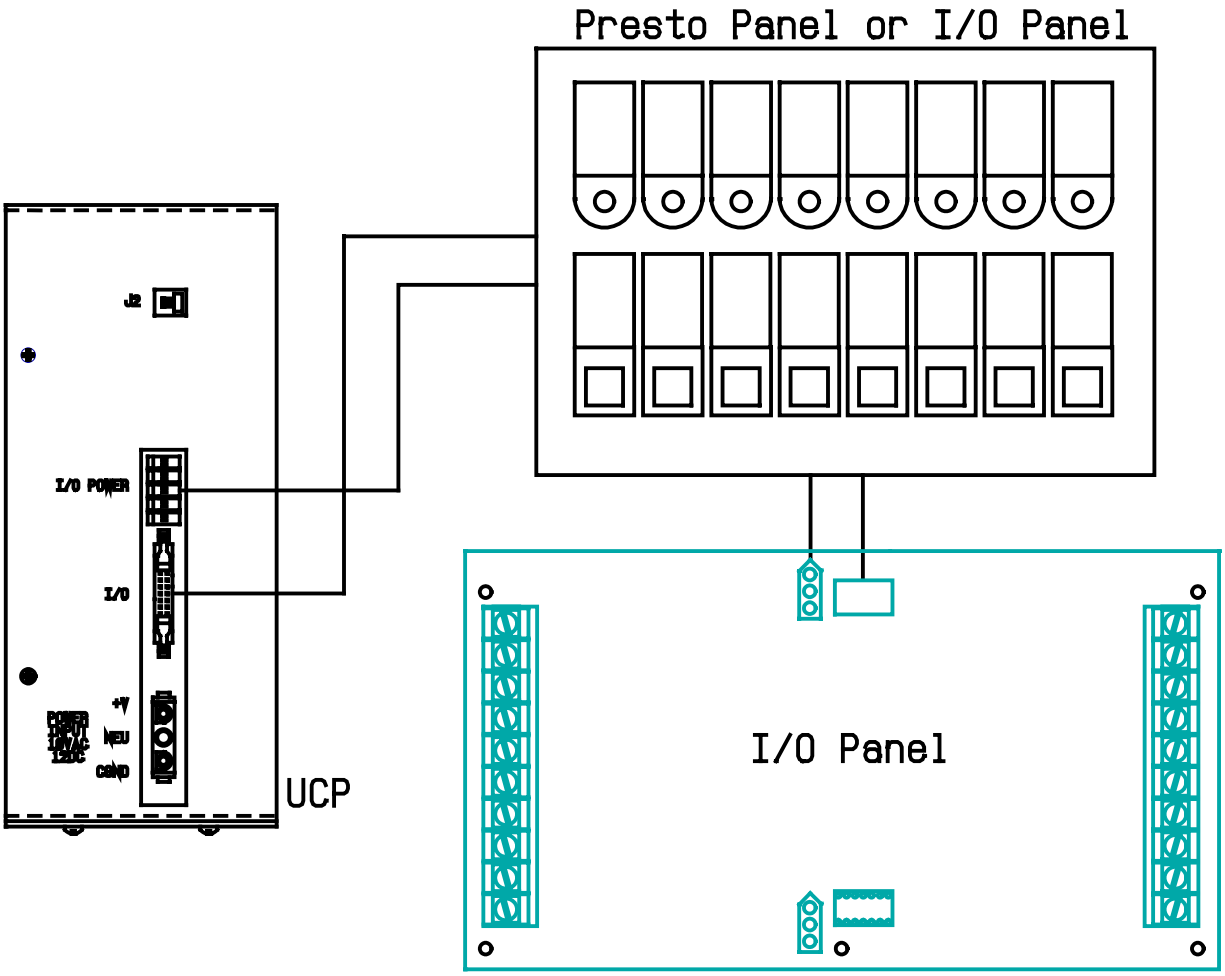
The optional D/A converter supplies two 12 bit, 0 to 10VDC output channels. D/A channels are written using the DAC statement, which accepts values between 0 (0 volts) and 32767 (10 volts). The DAC statement executes in about 400 microseconds. This option can be included on the 0-5VDC A/D converter board.

H.2.5 4-20mA Digital to Analog Converter

The optional D/A converter supplies two 12 bit, 4 to 20mA output channels. Using the DAC statement, the output can be adjusted from 4mA (0 counts) to 20mA (32767 counts). This option can be included on the 4 to 20MA A/D board and the RTD, 4 to 20mA board. The output can drive a load of 500 ohms or less.

H.3 UCP Input and Output

The UCP I/O Bus allows up to 128 inputs and 128 outputs, using the standard Divelbiss Bear Bones Expanders and Presto Panel; I/O boards of different types can be intermixed in any combination. **Figure 41** shows how the boards are connected to the UCP. The DIN function is used to read the status of inputs, and the DOUT statement is used to control outputs. **Figure 42** shows how the expander I/O address is related to the UCP I/O number; note that the easiest way to specify an I/O address on the UCP is in hexadecimal.
Figure 41 – I/O Expander Connection Example



When programming with I/O boards, remember to take the response time of the board into account. Inputs may have debounce circuitry that delays the response to a signal change by 10 to 20 msec. Outputs may take 20 msec to change state; this will limit the pulse rate that can be generated.

Addr	Hex	Dec.	Addr	Hex	Dec.	Addr	Hex	Dec.	Addr	Hex	Dec.
0/0	$00	0	2/0	$20	32	4/0	$40	64	6/0	$60	96
0/1	$01	1	2/1	$21	33	4/1	$41	65	6/1	$61	97
0/2	$02	2	2/2	$22	34	4/2	$42	66	6/2	$62	98
0/3	$03	3	2/3	$23	35	4/3	$43	67	6/3	$63	99
0/4	$04	4	2/4	$24	36	4/4	$44	68	6/4	$64	100
0/5	$05	5	2/5	$25	37	4/5	$45	69	6/5	$65	101
0/6	$06	6	2/6	$26	38	4/6	$46	70	6/6	$66	102
0/7	$07	7	2/7	$27	39	4/7	$47	71	6/7	$67	103
0/8	$08	8	2/8	$28	40	4/8	$48	72	6/8	$68	104
0/9	$09	9	2/9	$29	41	4/9	$49	73	6/9	$69	105
0/10	$0A	10	2/10	$2A	42	4/10	$4A	74	6/10	$6A	106
0/11	$0B	11	2/11	$2B	43	4/11	$4B	75	6/11	$6B	107
0/12	$0C	12	2/12	$2C	44	4/12	$4C	76	6/12	$6C	108
0/13	$0D	13	2/13	$2D	45	4/13	$4D	77	6/13	$6D	109
0/14	$0E	14	2/14	$2E	46	4/14	$4E	78	6/14	$6E	110
0/15	$0F	15	2/15	$2F	47	4/15	$4F	79	6/15	$6F	111
1/0	$10	16	3/0	$30	48	5/0	$50	80	7/0	$70	112
1/1	$11	17	3/1	$31	49	5/1	$51	81	7/1	$71	113
1/2	$12	18	3/2	$32	50	5/2	$52	82	7/2	$72	114
1/3	$13	19	3/3	$33	51	5/3	$53	83	7/3	$73	115
1/4	$14	20	3/4	$34	52	5/4	$54	84	7/4	$74	116
1/5	$15	21	3/5	$35	53	5/5	$55	85	7/5	$75	117
1/6	$16	22	3/6	$36	54	5/6	$56	86	7/6	$76	118
1/7	$17	23	3/7	$37	55	5/7	$57	87	7/7	$77	119
1/8	$18	24	3/8	$38	56	5/8	$58	88	7/8	$78	120
1/9	$19	25	3/9	$39	57	5/9	$59	89	7/9	$79	121
1/10	$1A	26	3/10	$3A	58	5/10	$5A	90	7/10	$7A	122
1/11	$1B	27	3/11	$3B	59	5/11	$5B	91	7/11	$7B	123
1/12	$1C	28	3/12	$3C	60	5/12	$5C	92	7/12	$7C	124
1/13	$1D	29	3/13	$3D	61	5/13	$5D	93	7/13	$7D	125
1/14	$1E	30	3/14	$3E	62	5/14	$5E	94	7/14	$7E	126
1/15	$1F	31	3/15	$3F	63	5/15	$5F	95	7/15	$7F	127

The Addr column shows the Expander I/O address; the Hex column shows the UCP I/O number in hexadecimal form, while the Dec. column shows it in decimal form.

Figure 42 – Relation Between I/O Board Address and UCP I/O Number

H.4 Real Time Clock

The optional real time clock allows the Bear BASIC program to determine the time and date at any point. The clock is accessed using GETDATE, SETDATE, GETIME, and SETIME. On the UCP these statements take about 150 msec to complete (which is slower than the Boss Bear). The UCP GETDATE statement always returns 0 for the day of week.

H.5 Serial Ports

Many devices interface with other equipment using serial data transfer. The UCP provides two optional serial ports (**COM1** and **COM2**). Both ports support asynchronous serial transfer at baud rates between 150 and 19200 baud, using RS-232, RS-485, or RS-422.

RS-232 can connect two pieces of equipment using three conductor cable; it is generally used for short distances (up to 50 ft) in environments that don't have much electrical noise. RS-422 can connect two pieces of equipment using five conductor cable; it can drive much longer distances (up to 5000 ft) and is more immune to noise. RS-485 can connect up to 32 pieces of equipment in a multidrop network using three conductor cable; it can also drive long distances in noisy environments. Divelbiss supplies two types of COM port adapters: RS-232 and RS-422/485. These adapters plug into the back panel of the UCP and convert the serial data to the proper signal levels.

H.5.1 COM1

While at the command line prompt, COM1 is used to attach the console terminal, which is the main programmer's interface to the UCP. On power up, it is set to 9600 baud, no parity, 8 data bits, and 1 stop bit. At runtime, **COM1** is accessed as FILE 0; it may be used as a general purpose serial port. The **COM1** connector is a 9 pin male D connector; the pinout is given in **Figure 43**.

Pin	ID	Description
1	--	No connect
2	RX	Receive data
3	TX	Transmit data
4	DTR	Data Terminal Ready (+10 VDC)
5	GND	Signal ground
6	--	No connect
7	RTS	Request To Send (Output)
8	CTS	Clear To Send (Input)
9	--	No connect

Figure 43 – UCP COM 1 Connector Pin Out

Divelbiss can supply the following cables to connect the UCP COM1 port to a personal computer:

Part No.	Description

ICM-CA-28	9 pin female D to male 25 pin D, 6 ft long
ICM-CA-29	9 pin female D to female 25 pin D, 6 ft long

To set the operating mode for **COM1**, two I/O ports must be written to. Port 0 controls the number of data bits, stop bits, and whether parity is enabled; see Figure 44. I/O port 2 controls the baud rate and even/odd parity (if port 0 setup has enabled parity); see Figure 45. For example, the code OUT 0,97: OUT 2,13 sets **COM1** to operate at 300 baud, no parity, 7 data bits, and 1 stop bit; since parity is disabled, OUT 0,97: OUT 2,29 will set the same parameters. As another example, OUT 0,102: OUT 2,5 will set 1200 baud, 8 data bits,

Decimal	Hex	Binary	Description
96	$60	01100000	Start bit + 7 data bits + 1 stop bit
97	$61	01100001	Start bit + 7 data bits + 2 stop bits
98	$62	01100010	Start bit + 7 data bits + parity + 1 stop bit
99	$63	01100011	Start bit + 7 data bits + parity + 2 stop bits
100	$64	01100100	Start bit + 8 data bits + 1 stop bit
101	$65	01100101	Start bit + 8 data bits + 2 stop bits
102	$66	01100110	Start bit + 8 data bits + parity + 1 stop bit
103	$67	01100111	Start bit + 8 data bits + parity + 2 stop bits

Figure 44 – UCP COM Port Setup Parameters

Decimal	Hex	Binary	Description
0	$00	00000000	38400 baud, even parity
1	$01	00000001	19200 baud, even parity
2	$02	00000010	9600 baud, even parity
3	$03	00000011	4800 baud, even parity
4	$04	00000100	2400 baud, even parity
5	$05	00000101	1200 baud, even parity
6	$06	00000110	600 baud, even parity
13	$0D	00001101	300 baud, even parity
14	$0E	00001110	150 baud, even parity
16	$00	00010000	38400 baud, odd parity
17	$11	00010001	19200 baud, odd parity
18	$12	00010010	9600 baud, odd parity
19	$13	00010011	4800 baud, odd parity
20	$14	00010100	2400 baud, odd parity
21	$15	00010101	1200 baud, odd parity
22	$16	00010110	600 baud, odd parity
29	$1D	00011101	300 baud, odd parity
30	$1E	00011110	150 baud, odd parity

even parity, and 1 stop bit. The SERIALDIR statement controls the state of the RTS output. The CTS input is always enabled; if CTS goes low, COM1 will stop transmitting.

Figure 45 – UCP COM Port Baud Rate Parameters

H.5.2 COM2

COM2 is unused while at the command line prompt. At runtime, it may be accessed as FILE 5 as a general purpose serial port, or it can be used to link the UCP into the Bear Direct network. On power up, it is set to 9600 baud, no parity, 8 data bits, and 1 stop bit. The **COM2** connector is a 9 pin male D connector; the pinout is given in Figure 46.

RS-422

Pin	ID	Description
1	TX-	Transmit data (-)
2	--	No connect
3	--	No connect
4	RX-	Receive data (-)
5	GND	Signal ground
6	RX+	Receive data (+)
7	--	Jumper to 8
8	--	Jumper to 7
9	TX+	Transmit data (+)

RS-485

Pin	ID	Description
1	TX-	Data (-)
2	--	No connect
3	--	No connect
4	--	No connect
5	GND	Signal ground
6	--	No connect
7	--	Jumper to 8
8	--	Jumper to 7
9	TX+	Data (+)

RS-232

Pin	ID	Description
1	--	No connect
2	RX	Receive data
3	TX	Transmit data
4	--	No connect
5	GND	Signal ground
6	--	No connect
7	RTS	Request To Send (Output)
8	--	No connect
9	--	No connect

Figure 46 – UCP COM 2 Connector Pin Out

To set the operating mode for **COM2**, two I/O ports must be written to. Port 1 controls the number of data bits, stop bits, and whether parity is enabled; see Figure 44. I/O port 3 controls the baud rate and even/odd parity (if port 1 setup has enabled parity); see **Figure 45**. For example, the code `OUT 1,97: OUT 3,13` sets **COM2** to operate at 300 baud, no parity, 7 data bits, and 1 stop bit; since parity is disabled, `OUT 1,97: OUT 3,29` will set the same parameters. As another example, `OUT 1,99: OUT 3,20` will set 2400 baud, 7 data bits, odd parity, and 2 stop bits.

To operate **COM2** in RS-422 mode, the line driver must be put into transmit mode, using the code `SERIALDIR 5,1`; this need only be done once, at the beginning of the program. When operating in RS-485 mode, the line driver must be switched between transmit and receive mode; in an RS-485 multidrop network, only one unit can be in transmit mode at any given time. As before, the code `SERIALDIR 5,1` sets it to transmit. After all characters

have been sent, allow at least two extra character times (ie. 2 msec at 9600 baud), then set the driver to receive mode using SERIALDIR 5,0.

H.5.3 Dual Switching RS-232 Serial Port

The optional dual switching port module is composed of two components: the internal serial switching module and the external dual serial port. The dual RS232 serial port allows the user to switch between ports A and B on the external board. The optional module can be used on Com1 and/or Com2.

The SERIALDIR statement is used to select between the A and B serial ports. SERIALDIR File, port is the syntax required to select active ports. The file is an integer expression where 0=COM 1 and 5=COM 2. The port is an integer expression where 0=port A and 1=port B. Note this is an adaptation of the SERIAL DIR statement and the user should review the SERIALDIR statement for standard operations.

In this example the COM 2 ports, A and B, are alternating print jobs. Because the switching of ports A and B is a mechanical one, a WAIT statement is required after the SERIALDIR statement.

EXAMPLE:

```
10    INTEGER X,Y                          Declaring X & Y as integer variables
20    X=0: Y=0                             Setting X & Y = 0
30    FILE 5                               Setting COM 2 active
40    OUT 1,100: OUT 3,18                  Setting operations mode for COM 2.
   START BIT + 8 BITS + NO PARITY + 1 STOP BIT--9600 BAUD (see 7.6.2 for details)
50    SERIALDIR 5,0: WAIT 20               Setting port A active--WAIT statement
                                           insures sufficient switching time.
60    X=X+1                                Incrementing X
70    PRINT "COM2 Channel A";X: WAIT 100   Printing text and the value of X to
                                           port A
80    SERIALDIR 5,1: WAIT 20               Setting port B active--WAIT statement
                                           insures sufficient switching time.
90    Y=Y+1                                Incrementing Y
100   PRINT "COM2 Channel B";Y: WAIT 100   Printing text and the value of Y to
                                           port B
110   GOTO 50                              Program control loop
```

When utilizing the CHAIN command, the user must reinitialize the file 5 and specify either A or B ports when returning from other programs.

Dual RS-232 Pin Out					
Pin (Port A)	ID	Descripton	Pin (Port B)	ID	Description
1	--	No Connect	1	--	No Connect
2	RX	Receive Data	2	RX	Receive Data
3	TX	Transmit Data	3	TX	Transmit Data
4	--	No Connect	4	--	No Connect
5	GND	Signal Ground	5	GND	Signal Ground
6	--	No Connect	6	--	No Connect
7	CTS	Clear to Send	7	--	No Connect
8	RTS	Request to Send	8	--	No Connect
9	--	No Connect	9	--	No Connect

***Note that CTS is supported by Port A, COM1 only.**

H.6 Nonvolatile Memory

Nonvolatile memory retains its state with the system power turned off. The UCP supports two types of nonvolatile memory as options: Touch Memory, and battery backed up RAM. Each of these has characteristics that make it more suitable for some applications.

H.6.1 Touch Memory

The UCP uses a Dallas Touch Memory in place of the EEPROM that is available in the Boss Bear; under most circumstances, the Touch Memory can be treated just like an EEPROM. The Touch Memory requires no power to retain its state; it can even be moved from one unit to another without affecting its contents. Touch Memory technology provides at least ten years of data retention. Unfortunately, it takes approximately 150 milliseconds to read or write each word in a Touch Memory. This makes the Touch Memory most suitable for values that aren't written to very often, such as configuration and calibration data. If a value must be read frequently, it should be copied from Touch Memory into a BASIC variable. The UCP Touch Memory holds 224 words (448 bytes). Bear BASIC uses the EEPOKE and EEPEEK statements to access the Touch Memory.

H.6.2 Battery Backed Up RAM

The UCP has a battery back up option for the system RAM. With this option installed, the UCP memory will be retained for approximately 10 years without power. The battery

backed up RAM is most suitable for values that change often, such as production information. When a BASIC program is started, the RAM is not modified, except by the BASIC program itself. This means that the variables will all have the same values that they held when power was removed.

Note that every time the UCP is turned on, the compiler is initialized, which deletes the BASIC source code. This does not affect the runtime memory area, so the variable values will be unchanged. This allows the programmer to leave information in BASIC variables; it will be retained while the UCP is without power.

H.7 Automatically Running a Program On Power-Up

When the UCP is powered up, it will automatically run the last program code that was saved to flash EPROM. If no code is found on the flash EPROM, then it will run the compiled code in RAM, if there is any. To prevent the UCP from automatically running a program on power-up, press the CLEAR key while power is being turned on; this will cause the UCP to issue the command-line prompt and wait for a command to be entered. If the CLEAR key is held down while the BYE command is entered, the UCP will go straight to the command line. A CTRL-C received on File 0 within the first second will function the same as the Clear key.

H.8 Flash EPROM

The UCP uses flash EPROM to store the user's source code and compiled programs. Unlike an EPROM, which is erased using an ultraviolet light, a flash EPROM is erased electrically, without removing the flash EPROM from the UCP. This erase operation is performed with the CLEARFLASH command, and takes several seconds to complete. The flash EPROM can be erased at least 1000 times.

The flash EPROM can be replaced with a battery-backed SRAM, which is erased and programmed just like a flash EPROM, using the CLEARFLASH and SAVE commands, respectively.

H.9 Display

The UCP can have one of three different types of displays.

2 rows by 20 characters LCD (Liquid Crystal Display)
2 rows by 20 characters backlit LCD
2 rows by 20 characters VFD (Vacuum Fluorescent Display)

The contrast on the LCD can be adjusted in the same manner as the Boss Bear.

Clear & F1- increase contrast
Clear & F2- decrease contrast

Unlike the Boss Bear the VFD intensity can also be controlled.

Clear & F1- increase brightness
Clear & F2- decrease brightness

Note: The VFD always powers up in full brightness.

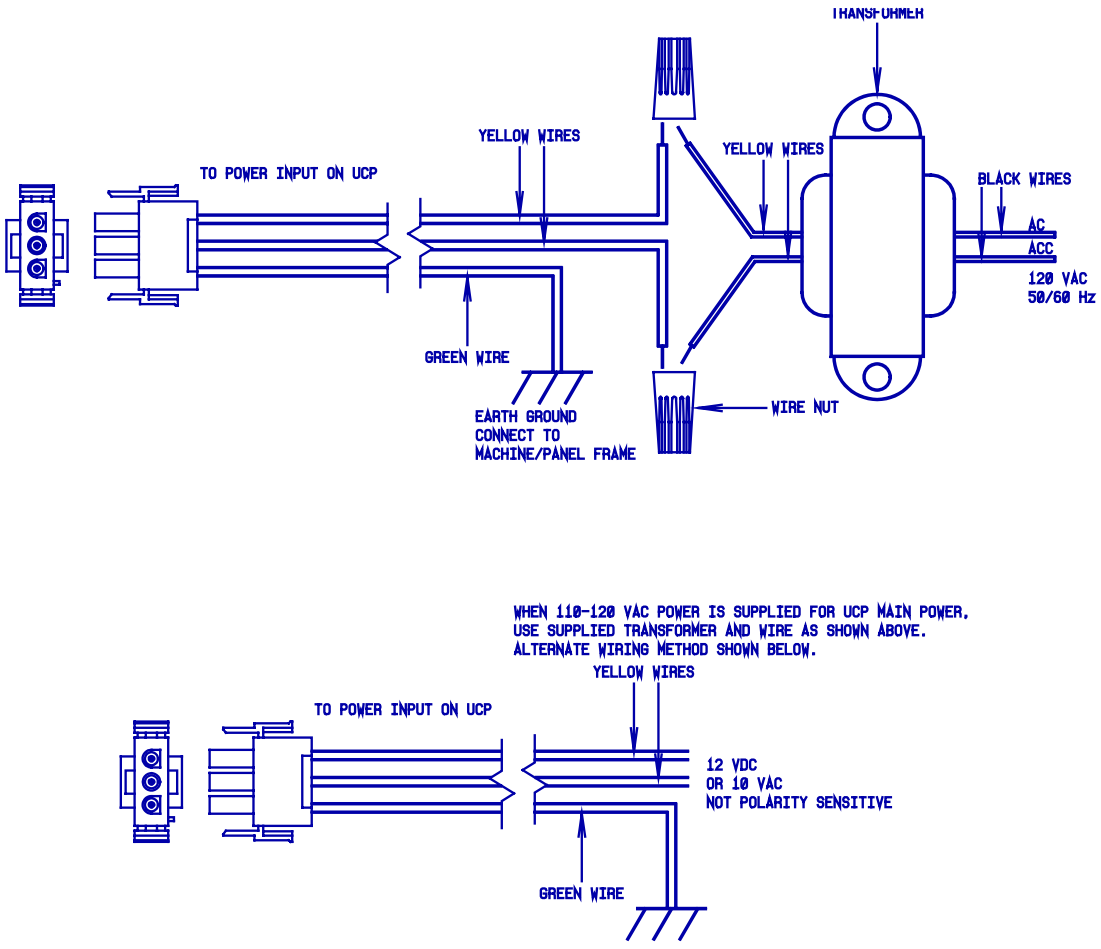


Figure 47 – UCP Power Supply Wiring Schematic

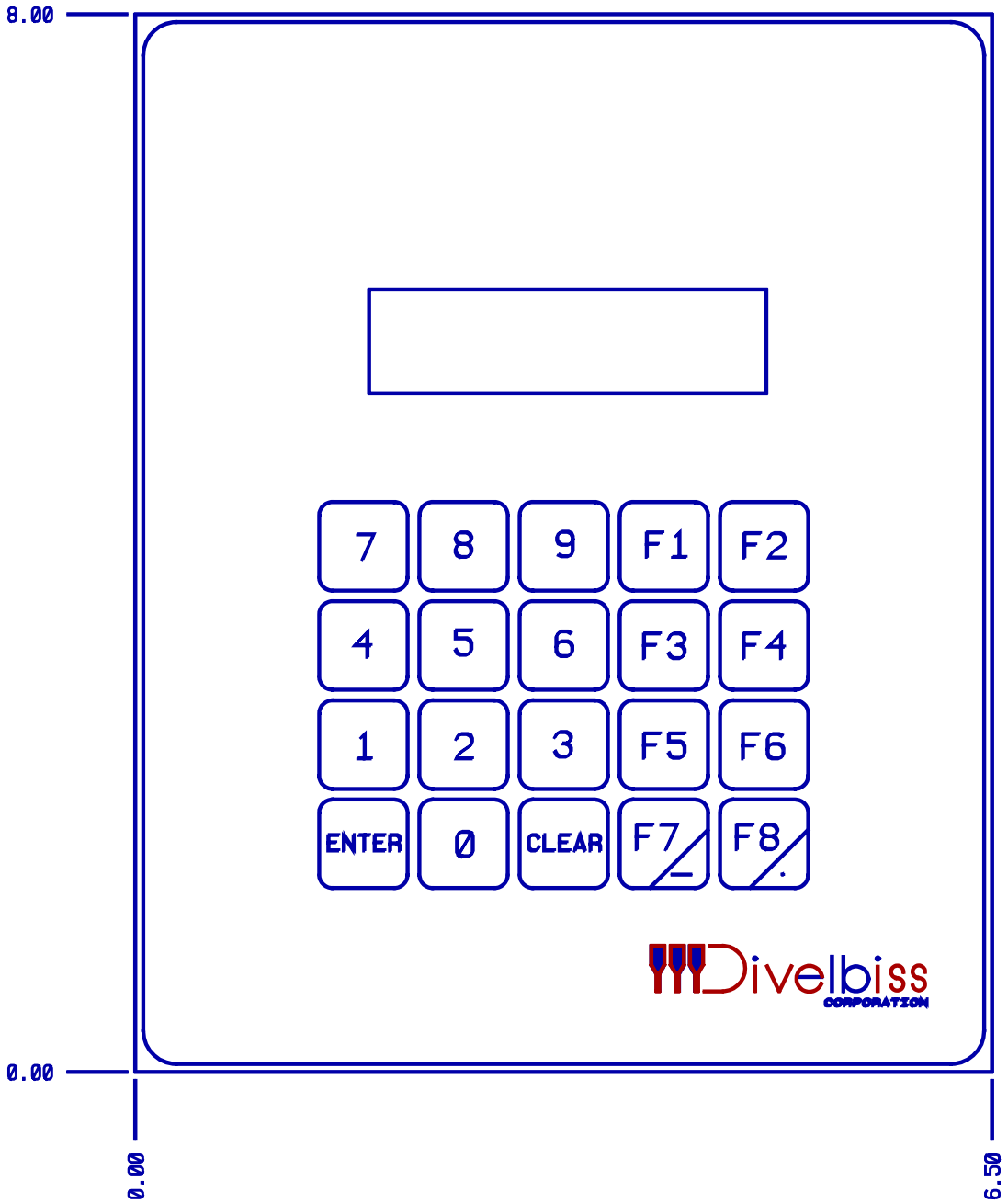


Figure 48 – UCP Front Panel

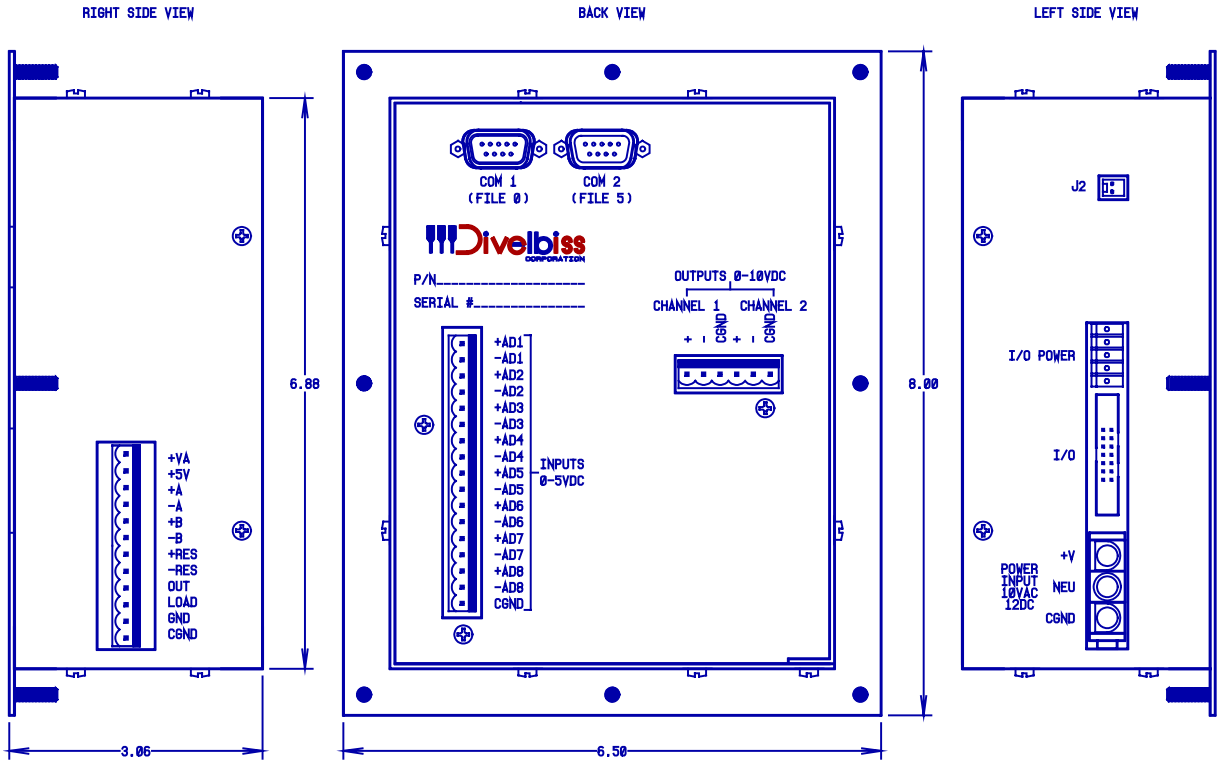


Figure 49 – UCP Back Panel Detail

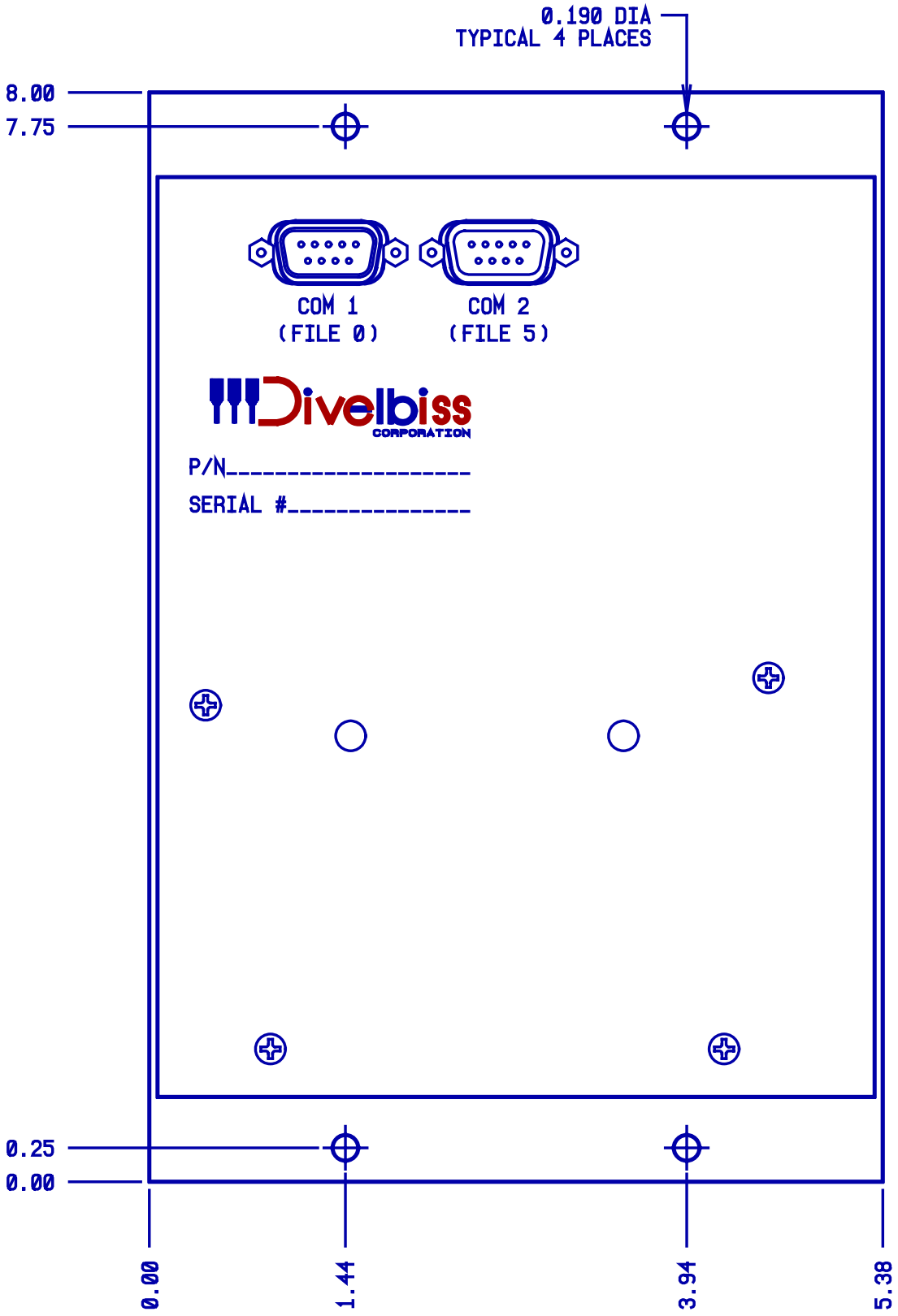


Figure 50 – UCP Back Panel for Plain Unit

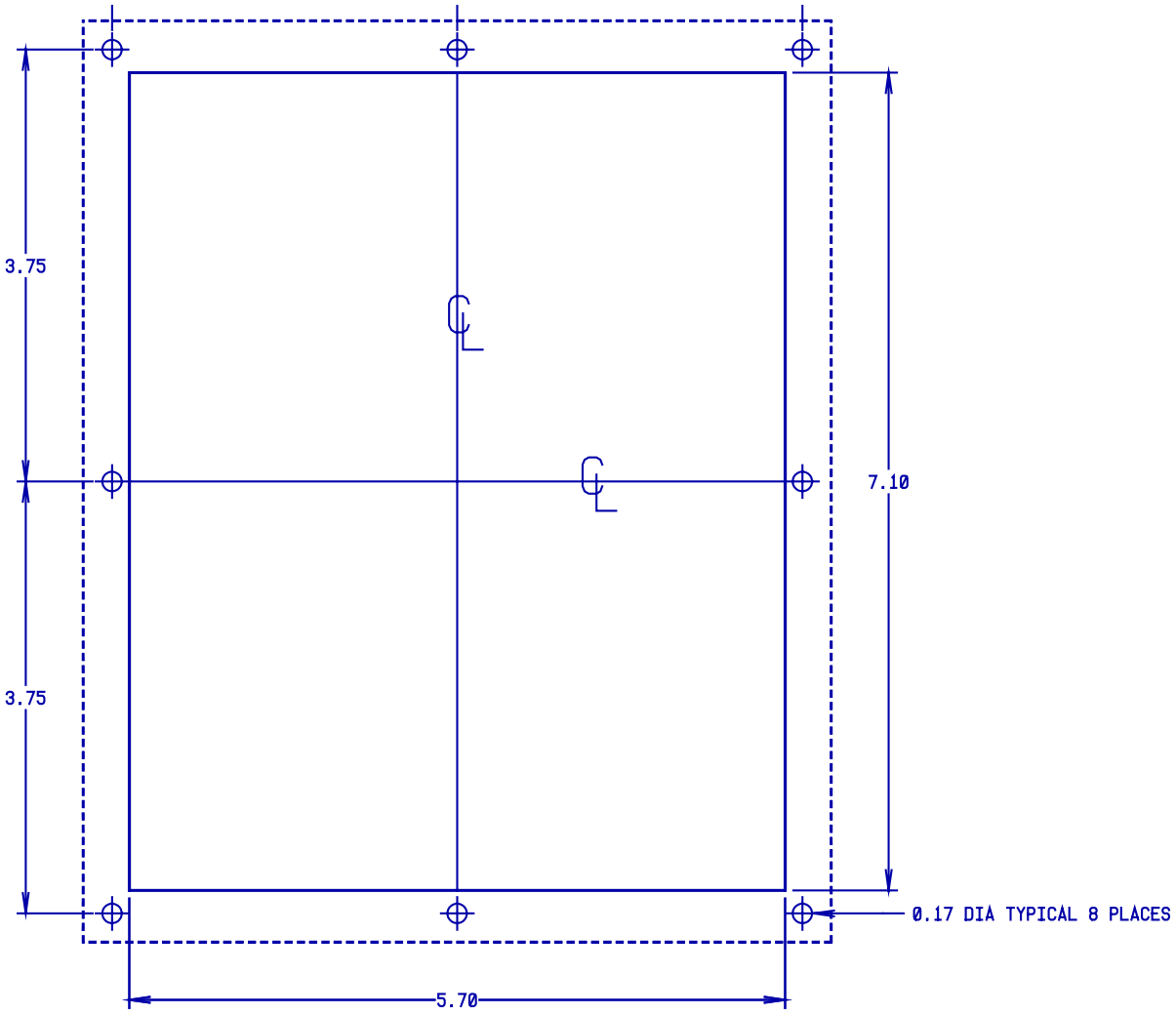


Figure 51 – UCP Panel Cut Out Template

H.10 Digital I/O Board (4 in, 4 out)

DC INPUT/OUTPUT SPECIFICATIONS:

INPUTS

Input Voltage: 10-32VDC

Turn-on Level: 8VDC @ 2.3 mADC MIN.
Turn-off Level: 2.5VDC @ 0.05 mADC MAX.

Turn-on Time: 30mS Nominal
Turn-on Time: 2□S Nominal

Isolation, Input-To-Logic Level: 3.6KV MIN. for 1 second.
Isolation, Interchannel: 3KV MIN. for 1 second.

Static Input Resistance: 2KOhm Nominal

OUTPUTS

Nominal Source Voltage: 24VDC (30VDC MAX.)

"On" State Voltage Drop: 2.4VDC MAX. @ 1 AMP.

Load Current: 0.5mADC MIN., 0-55 Deg. C
Load Current: 1 AMP. MAX., 0-55 Deg. C

Surge Current: 2 AMP. MAX. for 1 second @ 55 Deg. C

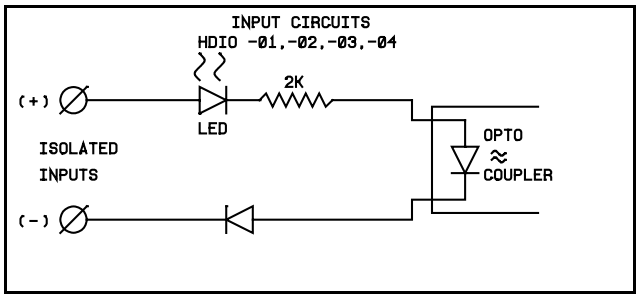
"Off" State Leakage Current: 100□ADC MAX. @ 30VDC, 0-55 Deg. C

Turn-on Time: 10□S MAX.
Turn-off Time: 1mS MAX.

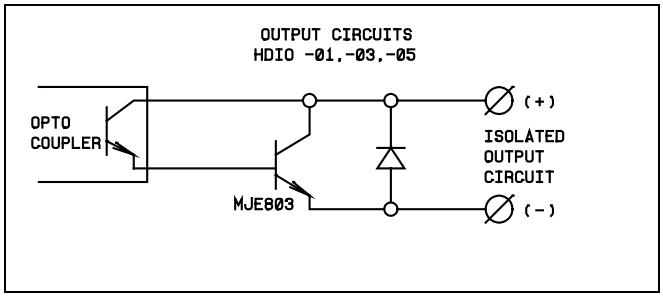
Isolation, Output-To-Logic Level: 3.6KV MIN. for 1 second
Isolation, Interchannel: 3KV MIN. for 1 second.

ON BOARD ISOLATED INPUT/OUTPUT CIRCUIT DIAGRAMS:

INPUT

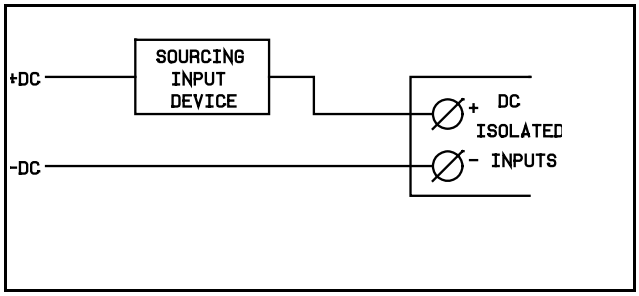


OUTPUT

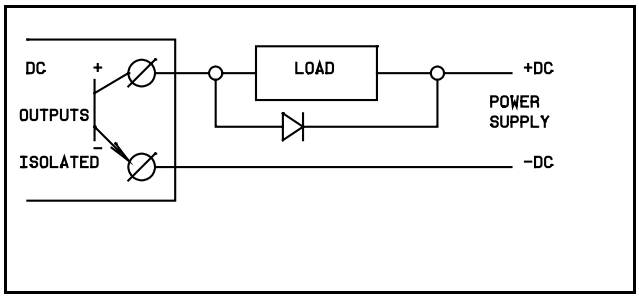


WIRING DIAGRAMS:

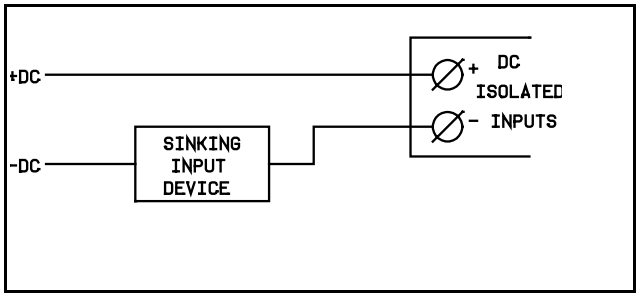
SINKING INPUT



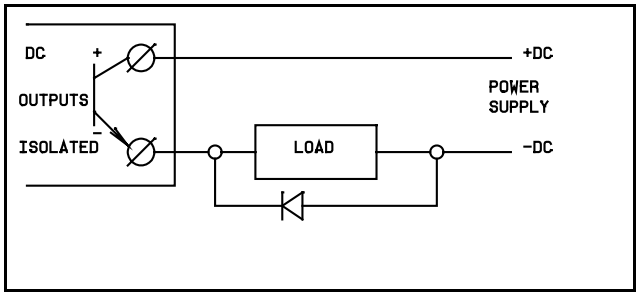
SINKING OUTPUT



SOURCING INPUT



SOURCING OUTPUT



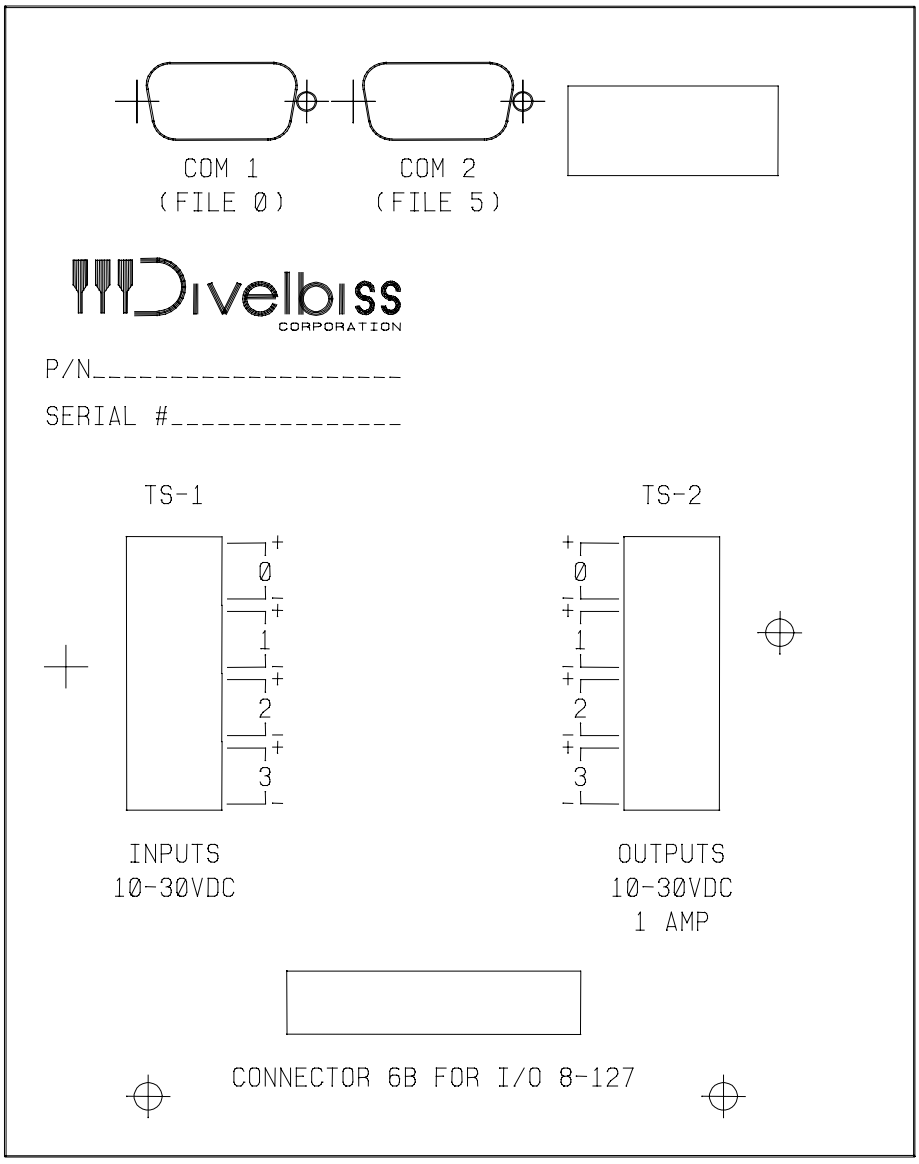


Figure 58 – Digital I/O Board Back Panel Detail (4 In / 4 Out)

Appendix I
Using Fuzzy Logic

I.1 Fuzzy Logic Fundamentals

I.2 Using the Fuzzy Statement

I.3 Applications and Examples of Fuzzy Logic

I.4 Conclusion

This document describes using Fuzzy Logic with the Universal Control Panel (UCP) and Boss Bear. Fuzzy Logic, as described in this document, is a methodology for using the know-how of experts in the implementation of control systems. In its most basic form, Fuzzy Logic is based onrigorous mathematical theory involving numerous calculations. Superior results to that of conventional control systems (PID ...) have been documented in applications ranging from elevator control to flight control in Navy aircraft. Because of this, Divelbiss Corporation has decided to make this exciting technology available using its general purpose controllers.

For simplicity, our Fuzzy Logic approach requires only variable declarations, minimal data setup, and an easy to use callable BEARBASIC statement, *FUZZY. FUZZY* will make all of the calculations required by Fuzzy Logic transparent to the user, thus requiring only the know-how of the user to implement a sophisticated control system.

This document is organized into three sections; 1) Fuzzy Logic Fundamentals, 2) Using the *FUZZY* statement, and 3) Examples / Applications. Section 1 will give some of the basic definitions of Fuzzy Logic and describe the technology from the end-user's point-of-view. Section 2 describes how to use the BEARBASIC statement *FUZZY* to implement Fuzzy Logic on the UCP and Boss Bear. And finally, Section 3 will provide some simple, yet real-world examples of using Fuzzy Logic.

I.1 Fuzzy Logic Fundamentals

Figure 59 shows a block diagram of a typical fuzzy system. Figure 60 describes in greater detail the Fuzzy Control Block of Figure 59.

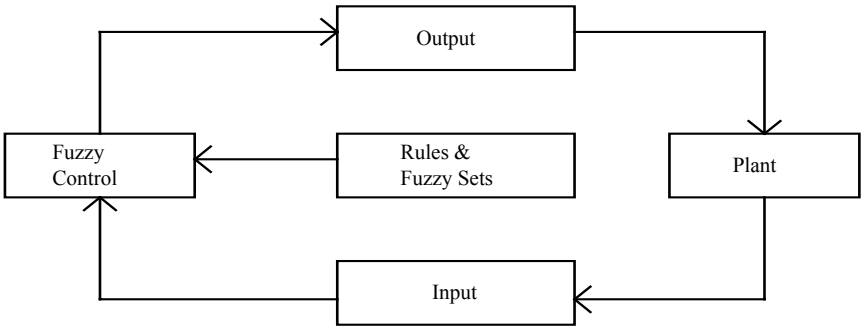


Figure 59 – Typical Fuzzy Control System

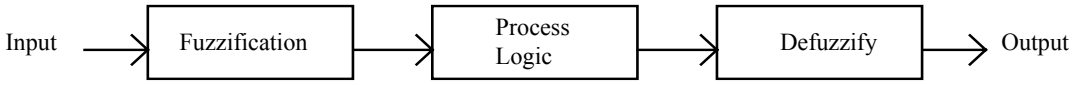


Figure 60 – Fuzzy Control Block

The definitions for each of the elements of the control system and control block have been provided below. Although confusing now, these definitions will become clear by the end of this section.

- Plant: Device or process to be controlled
- Input: Data feedback from the plant (i.e., pressure, speed, angle, position, ...)
- Output: Result of the control block which is output to the plant
- Fuzzy Control: Strategy for controlling the plant
- Rules & Fuzzy Sets: Your knowledge of the system being controlled
- Fuzzification: Transforming the input into values related to your fuzzy sets
- Process Logic: Your rules which guide the operation of the control system
- Defuzzify: Process to convert the output of the Process Logic to the actual output

I.1.1 "Fuzzy" Thinking

I.1.1.1 Fuzzy Sets and Membership Functions

Before a firm grasp of Fuzzy Logic basics can be obtained, an overview of some "fuzzy" thinking is required. Absolutes must be forgotten when considering fuzzy logic. Concepts like "IF YOU ARE 6 FEET IN HEIGHT YOU ARE TALL" must be replaced by "IF YOU ARE *AROUND* 6 FEET IN HEIGHT THEN YOU BELONG TO THE CLASS OF TALL PEOPLE". The basic idea is that nothing is absolute but everything is fuzzy, and thus the name Fuzzy Logic. Consider a system where an input is the height of a person. As humans, we might describe height with language such as {VERY SHORT, SHORT, AVERAGE, TALL, VERY TALL}, and avoid saying that any one of these descriptions is an exact number. For instance, we might agree that someone who is VERY SHORT could have a height which is less than 5'. SHORT may vary from 4' 6" to 5' 6", AVERAGE from 5' to 6', TALL from 5' 6" to 6' 6", and VERY TALL anybody who is greater than 6'. Note that each description

involves a range of heights and all of the different descriptions actually overlap. To draw this out graphically, each of our five fuzzy sets might look like Figure 61.

The horizontal axis of Figure 61 is the input values and the vertical axis is the degree of membership having values between 0 and 1. Take as an example someone who is 5' 10" in height. In reality, that person is somewhat AVERAGE and somewhat TALL. According to Figure 61, if you were to draw a vertical line at 5' 10" you would intersect lines belonging to fuzzy sets AVERAGE and TALL at around 0.4 and 0.6, respectively. Such an individual (according to our fuzzy sets) belongs to the set of people described by AVERAGE and TALL. This is the way in which all inputs and outputs of a Fuzzy Control block are handled. The inputs/outputs are identified, divided into subgroups (fuzzy sets), and given names.

One thing to note is that the triangular shapes of the fuzzy sets in Figure 61 may be replaced by other common shapes such as a bell and trapezoid. However, throughout this document all fuzzy sets will be addressed as triangles because that is the shape available when using the *FUZZY* statement to be described in detail later.

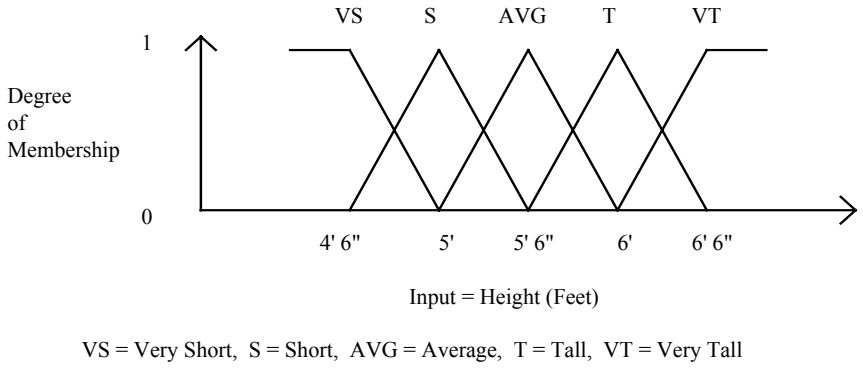


Figure 61 – Membership Functions for Input Height

I.1.1.2 Process Logic

The next step in Fuzzy Logic processing is to operate on the fuzzified input with process logic. This logic is the rules which guide the operation of the control system and are entered by you, the expert of the system. All process logic is in the form of *IF ... THEN* statements. An excellent, real world example is the way in which we operate the accelerator of a car. Consider that our desire is to maintain the speed of the car at 55 MPH. A couple of typical rules which might govern the way we think are:

IF OUR SPEED ERROR IS POSITIVE SMALL AND OUR RATE OF CHANGE IS NEGATIVE SMALL *THEN* CHANGE THE ACCELERATOR ZERO.

IF OUR SPEED ERROR IS NEGATIVE LARGE AND OUR RATE OF CHANGE IS ZERO *THEN* CHANGE THE ACCELERATOR POSITIVE LARGE.

In other words, Rule 1 is saying that the car is going a little faster than we want, but we are decreasing in speed so don't change anything. Rule 2 suggests that we are going much slower than we would like and not currently increasing or decreasing in speed so punch on the accelerator. This simple example clearly shows that a system to control the accelerator of a car would require a minimum of two (2) inputs and one (1) output. The inputs would be the current speed error and the rate of change of speed and the output would be the change to the accelerator. The inputs and output would be divided into subgroups, labeled such things as NEGATIVE LARGE, NEGATIVE SMALL, ZERO, POSITIVE SMALL, and POSITIVE LARGE, and the process logic which guides the control system is simply the way in which you, as an expert of operating a car accelerator, would react.

I.1.1.3 Defuzzification

Defuzzification is the process by which the applicable rules for a given situation are transformed into an actual output suitable for control of the plant. In the example described above for controlling the accelerator of a car this would be change in force on the pedal. Because in Fuzzy Logic it is not unusual for several output fuzzy sets to be affected by the input data, there must be a method for determining the actual output. Although there are several methods, the most common technique is centroid defuzzification. Centroid defuzzification takes the center of mass of all applicable outputs as the result. Consider that both inputs were operated on by the process logic and three output rules were "fired"; ZERO, POSITIVE SMALL, and POSITIVE LARGE. Through some standard calculations of Fuzzy Logic it was determined that ZERO, POSITIVE SMALL, and POSITIVE LARGE had degree's of membership of 0.30, 0.35, and 0.65, respectively. The actual output would be the centroid of all of the fired outputs. This process is shown graphically in Figure 62.

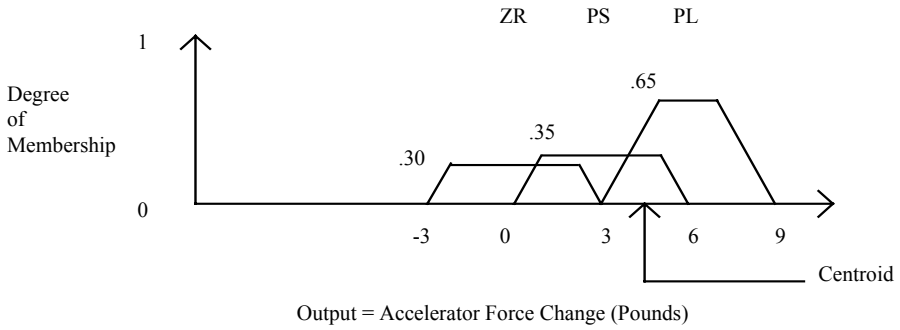


Figure 62 – Centroid Defuzzification

Thus, using defuzzification a plant (system) can be controlled when used in conjunction with your expertise and experience encoded in the input / output fuzzy sets and process logic.

I.1.2 Selecting Inputs and Outputs

A logical concern in a Fuzzy Logic application is what inputs are essential to the successful implementation of the system. To put it simply, the designer must have a thorough understanding of the system and Fuzzy Logic fundamentals. A good design practice might be to first ensure complete system understanding, ask yourself what are the variables you would use to control the system, and then implement the system. As an example consider our Fuzzy Logic control of the car accelerator. Common sense dictates that a minimum of two input variables are required, speed error and rate of change of speed. Without these two pieces of information our mind could not even control a car's accelerator. Thus, as a rule of thumb, always start with what appears to be the minimum number of inputs and then add additional inputs and process rules as increased performance dictates.

I.1.3 Selecting Fuzzy Set Values

After inputs and outputs have been selected, the next step is to determine exactly what names and values are to be placed on the fuzzy sets. A general overview can be obtained by carefully considering Figures 61 and 62. However, specifics can only be obtained with an example. Therefore, as a trial problem let us try to determine the appropriate fuzzy sets for a simple speed control problem. Just as the problem in controlling the car accelerator, the logical inputs to the Fuzzy Controller are the speed error and the rate of change of speed. An appropriate system output might be the change in the speed. Appropriate fuzzy sets for all three of these might be labeled {NEGATIVE LARGE, NEGATIVE SMALL,

ZERO, POSITIVE SMALL, POSITIVE LARGE} for a system with five (5) fuzzy sets per input or output. The next problem is to determine where are the starting and ending points for the fuzzy sets. Review Figures 63, 64, and 65 for schematic representations of these inputs and outputs to the Fuzzy Controller.

The objective in a speed control is to reach the desired speed (setpoint) as smooth as possible, in the fastest time, and without going over (overshoot) or oscillating around the setpoint. To avoid oscillations and to increase the chances of smooth control, it is generally good practice to cover the entire range of the input with the membership functions. Thus, in this case a good choice might have POSITIVE SMALL centered at 40mph and POSITIVE LARGE centered at 80mph. You may be asking yourself the obvious question; How can a 40mph speed error be considered small!! By reviewing Figure 63 you can see that with POSITIVE SMALL centered at 40, the entire range actually spans from 0 to 80mph and POSITIVE LARGE from 40mph to indefinitely. Thus, a value of 40mph actually covers the entire range better than a small value. Additionally, in the actual implementation of this Fuzzy Controller one would find that the larger this value, the smoother the control. This is true because the transition from one fuzzy set to the next is quite large which prevents rapid, and sometimes uncontrolled, changes in the rules which are affected by your process logic. Note that the negative half of the membership functions are the same as the positive half with minus signs.

With input 1 complete, the next step is to determine appropriate values for fuzzy sets of input 2. Change in speed actually determines how much change between samples is considered small, large, and so on. Thus, the values of the fuzzy sets for input 2 actually depend on how often you sample inputs 1 and 2. Thus, a thorough understanding of the overall system design is critical to appropriately pick fuzzy set values. Assume that we sample the inputs every .1 seconds. A concept which agrees with common sense is that if we went from 0 to 60mph in 5 seconds this would be quite fast.

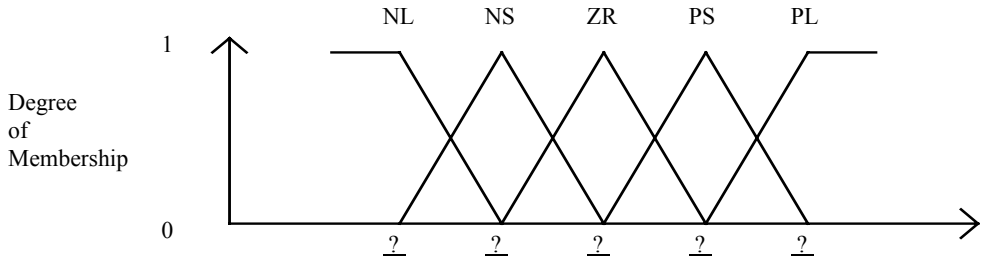


Figure 63 – Input 1: Speed Error Membership Function

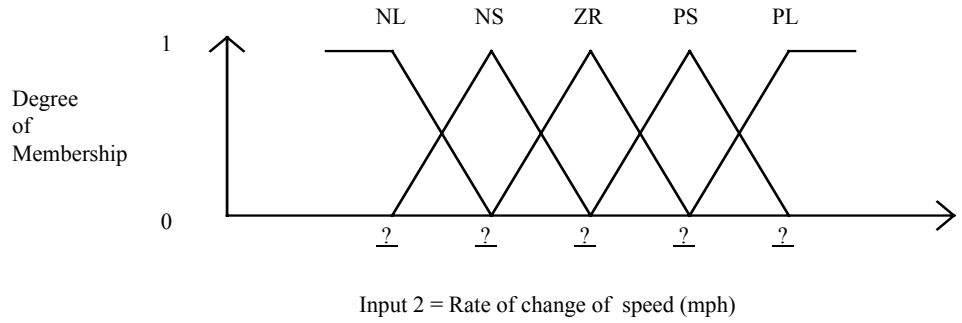


Figure 64 – Input 2: Rate of Change of Speed Membership Function

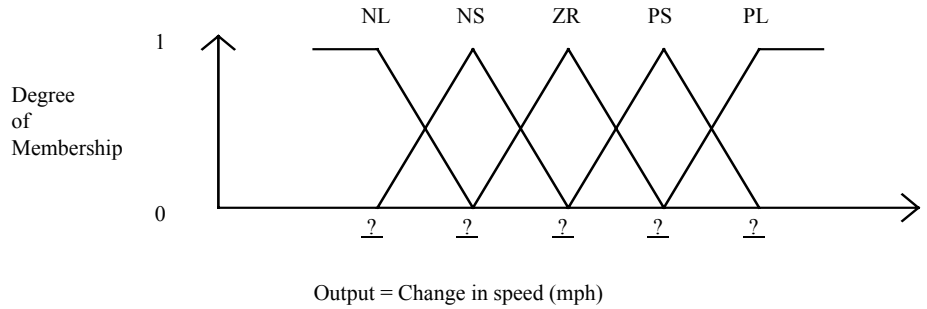


Figure 65 – Output 1: Change in Speed Membership Function

With some simple mathematics this works out to 1.2mph for every .1 second sample period (60 mph / (5 seconds * .1 seconds)). Thus, a reasonable center value for POSITIVE SMALL for input 2 might be 1.2mph. Once again, just as with input 1, if this value is too small, this will cause sudden and numerous changes in the output rules (which are affected by your process logic) and thus erratic operation. If this number is too big, the controller might never perceive its rate as being large (positive or negative) and thus will not behave correctly. Thus, common sense, knowledge of the system, and a basic understanding of fuzzy logic is required to appropriately select these values.

The last values to determine are those for the only system output, change in speed. The values assigned to the fuzzy sets for this output are also affected by the sampling time of the system. Additionally, a big consideration is the inherently slow response time of most cars to changes in speed. Thus, if the values for these fuzzy sets are too high, the system will be jerky and most likely unstable because every time a new output rule is affected by

your process logic, the transition will not be smooth. Additionally, if the input is too low, the system will get to the setpoint slowly. Once again conservative numbers are in order. An appropriate value might be 5-10mph for the center of POSITIVE SMALL.

The primary point to be remembered in the selection of fuzzy set values is to use common sense and moderation. In all cases, values which are extreme can cause unstable operation of the system. Especially before tuning a system, be conservative with the values to avoid damage, especially when the cost of erratic operation can be high.

I.1.4 Constructing Process Logic (Rule Tables)

Process logic is at the heart of why Fuzzy Logic provides an undisputed amount of flexibility in control systems design. Unlike conventional control technology, Fuzzy Logic control systems have the ability to take the expertise and human intuition of the user into account. This expertise is encoded into the controller in terms of process logic. Process logic are the rules which guide the operation of the system and are in the form of *IF...THEN* statements. Process logic is usually constructed in the form of rule tables as is described in Figure 66.

		SPEED ERROR				
		NL	NS	ZR	PS	PL
RATE OF CHANGE	NL	PL	PL	PL	PS	NL
	NS		PS	PS	ZR	
	ZR		PS	ZR	NS	
	PS		ZR	NS	NS	
	PL		NS	NL	NL	

Figure 66 – Example Rule Table for Speed Control

IF SPEED ERROR IS POSITIVE SMALL AND RATE OF CHANGE IS NEGATIVE SMALL *THEN* CHANGE SPEED ZERO.

or

IF SPEED ERROR IS POSITIVE LARGE *THEN* CHANGE SPEED NEGATIVE LARGE.

Such rules are based on expertise and intuition of how the controller should operate. The exact calculations depend on the input and output fuzzy sets, process logic, and some

standard calculations required by Fuzzy Logic. Note that in some cases rules may not make sense. It is always in the best interest of the design to remove unnecessary rules to avoid excess processing. However, one should be quite certain when doing this because the rules represent knowledge, and a lack of knowledge can cause unpredictable results.

I.1.5 Tuning a Fuzzy Logic Controller

Once the system operation has been understood, inputs and outputs determined, and fuzzy sets generated, the next step is to simulate or implement the controller for verification. It is recommended that simulations of the system be performed first if such tools are available. Computer modelling of the process will increase the probability of creating a system with acceptable results during the first implementation. However, in some cases this recommended design approach may not be possible and the only way to ensure correct operation is to implement the controller in a real system and then tune the controller. Tuning of a Fuzzy Logic controller is required just as with conventional control systems. However, unlike tuning controllers such as PID (Proportional, Integral, Derivative), tuning a Fuzzy Logic controller is more intuitive because of the reliance on human experience. Typically, a Fuzzy Logic controller is not successful for the following reasons:

- Incorrect process logic
- Incorrect inputs and/or outputs
- Incorrect fuzzy set values
- An incorrect number of fuzzy sets

Tuning of a Fuzzy Logic controller involves modifying any or all of the four listed items above until acceptable system behavior is obtained. The first two items being incorrect typically results from a lack of understanding of the overall system prior to the implementation of the controller. Without the correct process logic the system cannot respond as desired. Having incorrect inputs and/or outputs sometimes results because other factors are more important in the system than they appear at first. Generally speaking, it is easier to change the process logic than the inputs and outputs because the latter may involve changing the overall system design (including hardware). Thus, understanding what needs to flow into and out of a Fuzzy Logic controller is critical from the outset of a design.

The last two items being incorrect could result because of a lack of understanding of Fuzzy Logic fundamentals. As described in section I.1.1.3, **Selecting Fuzzy Set Values**, it is not uncommon to be overly aggressive in selecting fuzzy set values. Being too aggressive with these values from the outset can result in unstable or erratic operation of the control system. Thus, it is generally a good practice to be very conservative in the initial implementation of the controller and tune the system up for more aggressive response after the initial implementation. This involves increasing the values for what might be considered

SMALL, etc. for the inputs and decreasing the values for what might be considered SMALL in the output. The previous statement is generally true for such applications as speed, position, and temperature control, just to name a few. With regards to the number of fuzzy sets, a good rule of thumb in many process control applications is to have between five (5) and nine (9) fuzzy sets for each input and/or output. As described in section I.2, the *FUZZY* statement contains two (2) inputs and two (2) outputs with seven (7) fuzzy sets, which is sufficient for most applications.

I.2 Using the *FUZZY* Statement

The Fuzzy Logic capabilities using the Universal Control Panel are entirely contained in one easy to use statement, *FUZZY*. *FUZZY* has been optimized for speed and simplicity over a broad range of applications. The *FUZZY* statement supports two (2) inputs and outputs, seven (7) fuzzy sets with symmetric triangles, user-definable fuzzy set values, and a return status. Execution of the *FUZZY* statement requires less than 1.0mS, providing sufficient speed for most single-loop applications. The format of the *FUZZY* statement using the Divelbiss BEARBASIC programming language is as follows:

FUZZY ADR(DATA VARIABLE 1), INPUT1, INPUT2, OUTPUT1, OUTPUT2, STATUS

where ADR(DATA VARIABLE 1) is the address of the first variable in the Fuzzy data list, INPUT1 and INPUT2 are integer variables which contain the input values passed to the statement within your BEARBASIC routine, OUTPUT1 and OUTPUT2 are integer variables which will contain the return values from the *FUZZY* statement and STATUS is an integer variable which contains the status of the Fuzzy processing.

The first item to be addressed is the Fuzzy variable list. In all there are 106 integer values which are required for the Fuzzy Logic processing using the *FUZZY* statement. The 106 integers consist of the midpoint and sensitivity values for INPUT1, INPUT2, OUTPUT1, and OUTPUT2, and the 49 rules for each output. For clarification on the midpoint and sensitivity values see Figure 67 which shows the shape and numbering scheme for the membership functions for inputs and outputs. The seven (7) fuzzy sets will always be labeled 1 through 7 with 1 being left-most and 7 right-most. In the division of the inputs and outputs these may be labeled by you as NEGATIVE LARGE, NEGATIVE MEDIUM, etc. However, for processing purposes these are given numerical values. Additionally, as described in Figure 67, all fuzzy sets are triangular in shape and symmetric about the mid-point. Membership functions of this shape give the additional advantage of only requiring the mid-point and the distance between triangles (sensitivity) to fully describe the function.

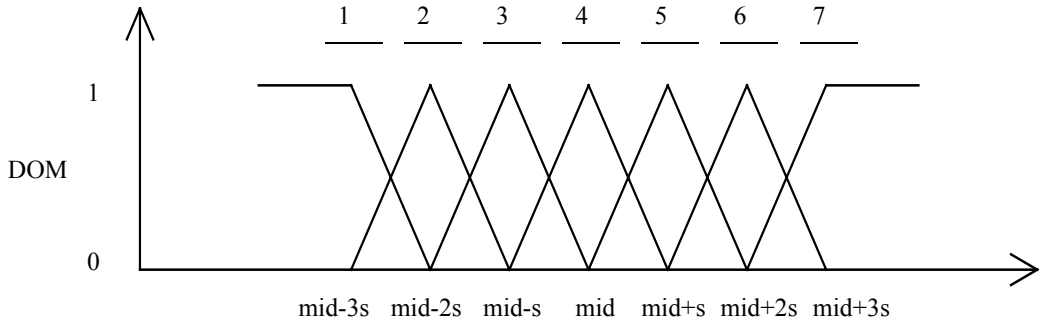


Figure 67 – Shape and Numbering Scheme for Inputs and Outputs using the Fuzzy Statement

The *FUZZY* statement can be utilized to solve your control problems once you have identified the problem, determined the inputs and outputs, divided these into 7 regions, and generated process logic. The following explanations will assume a working knowledge of the BEARBASIC programming language and thus only the portions of the code relating to the *FUZZY* statement will be addressed.

As stated, their are 106 integer data values which are required to successfully implement the *FUZZY* statement, and the variable declarations for these variables must be in successive order at the beginning of your BEARBASIC software. Because of this the simplest way to implement the data list is to declare all of the Fuzzy data as one large array, use the BEARBASIC DATA statement to enter the data, and then use the READ statement to enter the data into the declared variables. This minimizes the length of the software and makes the program easier to read and debug. **Note: The Fuzzy data must be declared as one array for the *FUZZY* statement to operate correctly**. Consider a problem requiring two (2) inputs and one (1) output with the following membership function shapes:

INPUT1 midpoint = 0
INPUT1 sensitivity = 15
INPUT2 midpoint = 0
INPUT2 sensitivity = 30
OUTPUT1 midpoint = 0
OUTPUT1 sensitivity = 4
OUTPUT2 midpoint = 0
OUTPUT2 sensitivity = 0

Additionally, the rule tables for OUTPUT1 and OUTPUT2 are described in Figures 68 and 69. Note that since OUTPUT2 is not required that the rule table contains all zero's along with having zero midpoints and sensitivities. As an example, the rule table for OUTPUT1

states that if INPUT1 is in division 3 and INPUT2 is in division 6 then OUTPUT1 responds within division 3.

To implement this controller using the BEARBASIC language and the *FUZZY* statement the first step is the variable declarations.

		INPUT1						
		1	2	3	4	5	6	7
INPUT2	1	7	7	6	5	6	5	4
	2	7	6	6	5	5	4	3
	3	7	6	5	5	4	3	2
	4	7	6	5	4	3	2	1
	5	6	5	4	3	3	2	1
	6	5	4	3	3	2	2	1
	7	4	3	2	3	2	1	1

Figure 68 – Rule Table for Output 1

		INPUT1						
		1	2	3	4	5	6	7
INPUT2	1	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0

Figure 69 – Rule Table for Output 2

Thus, the portion of a BEARBASIC program related to the *FUZZY* statement for this example might be as follows:

```
100    INTEGER IN1, IN2, OUT1, OUT2, ST
110    INTEGER FUZLOOP
120    INTEGER FUZDAT(106)

140    DATA 0,15
160    DATA 0,30
180    DATA 0,4
200    DATA 0,0


200    DATA 7,7,7,7,6,5,4
220    DATA 7,6,6,6,5,4,3
240    DATA 6,6,5,5,4,3,2
260    DATA 5,5,5,4,3,3,3
280    DATA 6,5,4,3,3,2,2
300    DATA 5,4,3,2,2,2,1
320    DATA 4,3,2,1,1,1,1

340    DATA 0,0,0,0,0,0,0
360    DATA 0,0,0,0,0,0,0
380    DATA 0,0,0,0,0,0,0
400    DATA 0,0,0,0,0,0,0
420    DATA 0,0,0,0,0,0,0
440    DATA 0,0,0,0,0,0,0
460    DATA 0,0,0,0,0,0,0

FOR FUZLOOP = 0 TO 105
READ FUZDAT(FUZLOOP)
NEXT FUZLOOP

IN1 = 20
IN2 = 5

FUZZY ADR(FUZDAT(0)),IN1,IN2,OUT1,OUT2,ST
```

The return values from the statement are contained in variables OUT1 and OUT2 which can then be manipulated as required in the remaining portion of your BEARBASIC software. The status variable, ST, will be; 0 if the processing occurred correctly, 1 if OUT2 was beyond the range of an integer, 2 if OUT1 was beyond the range of an integer, and 3 if

both outputs were beyond the range of an integer. When an output is beyond the range of an integer the return value from the *FUZZY* statement will be clamped at +32767 or -32767 depending on the actual sign of the output. The ST variable will contain a 0 in most circumstances and should only be checked in extreme cases.

A couple of things to note are that the data (all 0's) for OUTPUT2 are required even though this output is not being utilized and that the first value read into the data array is FUZDAT(0). Thus, the first value being passed to the *FUZZY* statement is the address of this variable (ADR(FUZDAT(0)).

The Fuzzy data to be read in must be in the order described above in the example routine. A summary of this order is provided below:

INPUT1 midpoint, sensitivity
INPUT2 midpoint, sensitivity
OUTPUT1 midpoint, sensitivity
OUTPUT2 midpoint, sensitivity

RULE OUTPUT1[IN1=1,IN2=1]	...	RULE OUTPUT1[IN1=1,IN2=7]
RULE OUTPUT1[IN2=1,IN2=1]	...	RULE OUTPUT1[IN1=2,IN2=7]
RULE OUTPUT1[IN3=1,IN2=1]	...	RULE OUTPUT1[IN1=3,IN2=7]
RULE OUTPUT1[IN4=1,IN2=1]	...	RULE OUTPUT1[IN1=4,IN2=7]
RULE OUTPUT1[IN5=1,IN2=1]	...	RULE OUTPUT1[IN1=5,IN2=7]
RULE OUTPUT1[IN6=1,IN2=1]	...	RULE OUTPUT1[IN1=6,IN2=7]
RULE OUTPUT1[IN7=1,IN2=1]	...	RULE OUTPUT1[IN1=7,IN2=7]

RULE OUTPUT2[IN1=1,IN2=1]	...	RULE OUTPUT1[IN1=1,IN2=7]
RULE OUTPUT2[IN2=1,IN2=1]	...	RULE OUTPUT1[IN1=2,IN2=7]
RULE OUTPUT2[IN3=1,IN2=1]	...	RULE OUTPUT1[IN1=3,IN2=7]
RULE OUTPUT2[IN4=1,IN2=1]	...	RULE OUTPUT1[IN1=4,IN2=7]
RULE OUTPUT2[IN5=1,IN2=1]	...	RULE OUTPUT1[IN1=5,IN2=7]
RULE OUTPUT2[IN6=1,IN2=1]	...	RULE OUTPUT1[IN1=6,IN2=7]
RULE OUTPUT2[IN7=1,IN2=1]	...	RULE OUTPUT1[IN1=7,IN2=7]

for a total of 106 data points (8 for midpoints and sensitivities, 49 for the rules for OUTPUT1, and 49 for the rules for OUTPUT2).

In summary, the *FUZZY* statement provides the simplest approach to the implementation of Fuzzy Logic controllers. Sophisticated control systems for a variety of applications can be implemented with very little programming using the Divelbiss Corporation UCP and Boss Bear.

A summary of the specifications for the *FUZZY* statement are provided below:

Number of Inputs:	2
Number of Outputs:	2
Number of Fuzzy Sets:	7
Fuzzy Set Shape:	Symmetric Triangular
Rules per Output:	49
Defuzzification Method:	Centroid
Approximate Execution Time:	0.5mS - 1.0mS
Number of Fuzzy Control Loops:	1

PLEASE NOTE THAT THESE SPECIFICATIONS ARE NOT FOR THE UNIVERSAL CONTROL PANEL BUT ONLY FOR THE *FUZZY* STATEMENT AVAILABLE IN THE BEARBASIC PROGRAMMING LANGUAGE. THE UNIVERSAL CONTROL PANEL IS A GENERAL PURPOSE CONTROLLER OF WHICH FUZZY LOGIC CONTROL IS ONE CAPABILITY.

PLEASE CONSULT THE FACTORY FOR INFORMATION REGARDING THE IMPLEMENTATION OF MULTIPLE CONTROL LOOPS USING THE *FUZZY* STATEMENT.

I.3 Applications and Examples of Fuzzy Logic

I.3.1 Is *FUZZY* Right for Your Application?

The majority of areas in which the *FUZZY* statement would be best suited occur in single loop process control applications. Some examples might be temperature, climate, speed, position, pressure, and fluid depth, just to name a few. All of these applications require at most two (2) inputs and usually one (1) output and thus would be well suited for Fuzzy Logic control using the UCP or Boss Bear. Additionally, because the UCP and Boss Bear are general purpose controllers, other applications can be handled simultaneously along with your real-time control requirements, providing maximum flexibility in system design.

One necessity when designing a control system is understanding the performance requirements of the loop. If conventional control techniques such as PID (Proportional, Integral, Derivative) have resulted in undesired behavior of the system such as slow response, excessive overshoot, and/or poor disturbance response, the Fuzzy Logic control capabilities using the UCP or Boss Bear might be the solution. Additional considerations are the ease of tuning and the long-term reliability of your control solution. As described earlier, Fuzzy Logic provides an intuitive approach to controller tuning which is not available with other techniques such as PID. Finally, it has been proven that a tuned PID control

loop is only good if the plant is reasonably stable over time. Any change in the plant such as weight, volume, etc. could result in erratic operation of the PID loop. However, Fuzzy Logic controllers are quite immune to variations in the plant dynamics, thus providing long-term reliability of the system without the need for extensive changes over the life of the system.

I.3.1 Fuzzy Logic Control Examples Using *FUZZY*

I.3.1.1 Motor Speed Control

An excellent, real-world example of using Fuzzy Logic is motor speed control. Speed control is a traditional problem of closed-loop control systems and is well understood by the majority of system designers. Fuzzy Logic control lends itself to this problem because this expertise can be mapped into the control system design. This is something which is not typically possible with traditional control design methodologies and demonstrates some of the exciting possibilities of this emerging technology in industry.

I.3.1.1.1 Problem Statement

The speed control problem is best defined as the tracking of the set-point speed of a motor with robust recovery from extreme set-point changes, external disturbances, and changes in plant dynamics.

I.3.1.1.2 Input / Output Definition

According to the problem statement the primary goal of the control system is to track the set-point speed of the motor. In order to accomplish this one must know how far from the set-point the system is and thus, a required input to the Fuzzy Logic controller is the current speed error defined as follows:

INPUT1: SPEED ERROR = (CURRENT SPEED) - (SET POINT)

Additionally, previous information about speed is critical. For instance, suppose at the current sample the speed turns out to be exactly at the set-point, but at the previous sample the speed was significantly below the set-point. Thus, in a short amount of time the speed increased significantly. Because no real system can stop instantaneously, it is quite

probable that at the next sample the system will be well above the set-point. Therefore, the rate of change of speed between samples is necessary in addition to the speed error:

INPUT2: RATE OF CHANGE = (CURRENT SPEED) - (LAST MEASURED SPEED)

A logical control output for the system is the change in the drive signal to the motor. This is logical because at all moments the system speed must be increased or decreased from its present value in order to track the set-point speed:

OUTPUT1: DRIVE SIGNAL CHANGE

I.3.1.1.3 Hardware Interface

Figure 70 describes the hardware design of this system. Notice that only one analog input, current speed, is required into the unit and not two as was defined in Section I.3.1.1.2. This is because the input/output definition for the Fuzzy Control is not necessarily the same as the input/output definition for the system. With some BEARBASIC programming, the set-point can be entered from the keypad. This setpoint can be compared with the current speed received from the transducer to arrive at INPUT1 required by the Fuzzy Control system. INPUT2 to the Fuzzy Control block can also be obtained through software programming from the current speed. Once the current speed is obtained, it can be compared to the previous sample to arrive at the rate of change. Once this calculation is made, the current speed may be saved as the old speed for use during the next sample.

Another important point is that the Fuzzy Logic control block has an output which is the change in the drive signal while the actual system output is simply the drive signal. With programming, it is possible to store the current drive signal and then add the Fuzzy Logic output to obtain the signal to transmit to the motor. This once again demonstrates that the input/output requirements of the Fuzzy Logic control block are not the input/output requirements of the system.

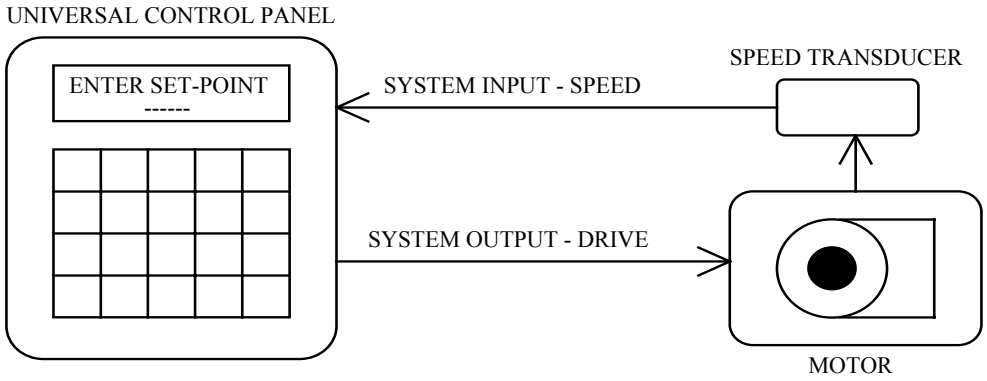


Figure 70 – Hardware Interface for Motor Speed Control

I.3.1.1.4 Membership Functions

The next step is to determine the membership functions for both inputs and the single output. See Figure 67 for a review of the membership functions utilized with the *FUZZY* statement. The two values to determine for each input and output are the sensitivity (s = distance between triangle centers) and the midpoint. For all of the inputs and outputs of this system, it is clear that the midpoint value is zero (0). This is because the goal for INPUT1 (speed error) is to have a value of zero (0) with the actual value being above or below the set-point. INPUT2 (speed rate of change) can also be zero with the actual value being above or below this. This argument is also true for OUTPUT1. Thus, the only values left to decide are the sensitivities for each input and output.

Sensitivity selection is dependant upon your expertise of the problem/process and some understanding of Fuzzy Logic fundamentals. As described in Section I.1.3, as the sensitivity for both inputs is decreased, the Fuzzy Logic controller becomes more sensitive to the error and rate of change, respectively. Therefore conservative values should be utilized in the initial attempt at selecting these values. A reasonable approach is to determine what would be considered a "large" value for each of the inputs/outputs and divide this number by three (3) to determine the sensitivity. Once again, in the initial design attempt it is best to enter larger values for both of these input sensitivities and a smaller output sensitivity to avoid erratic behavior. Remember, the controller can always be tuned for more aggressive behavior following the initial implementation. For purposes of demonstration, assume the set-point will be around 200rpms. Thus, to evenly divide the space, let a large error be 200, which makes the sensitivity for INPUT1 67. The sensitivity for INPUT2 depends on the sample time as described in Section I.1.3. For purposes of demonstration assume this sensitivity is 20. OUTPUT1 is the change in the output drive

signal, and in order to cover the whole space a reasonable sensitivity might be 67 just as INPUT1. However, to be conservative the first value to be implemented should be around 33. Once implemented, these values should be tuned in order to optimize the response of the system.

I.3.1.1.5 Process Logic

Figure 71 describes reasonable process logic for a speed control problem. If the speed error, INPUT1, is negative large, then regardless of the rate of change, INPUT2, change the output drive signal positive large. There are two important things to notice about the rule table: the closer to the zero (0) the speed error becomes, the more conservative the change in the output and the table is symmetric about INPUT1, only in the reverse direction.

Conservative behavior about the set-point is quite typical for most of the applications listed in Section I.3.1, **Is Fuzzy Logic Right for Your Application?**. This is because abrupt changes in the output around the desired value will most likely cause oscillations. Thus, the further away from the set-point, the more aggressively the output control action and visa-versa as the input approaches the set-point.

INPUT2 RATE OF CHANGE	INPUT1 SPEED ERROR 1	2	3	4	5	6	7
1	7	7	6	6	6	4	1
2	7	7	6	5	5	3	1
3	7	6	5	5	4	3	1
4	7	6	5	4	3	2	1
5	7	5	4	3	3	2	1
6	7	5	3	3	2	1	1
7	7	4	2	2	2	1	1

Figure 71 – Rule Table for Speed Control Example

With regards to the symmetry of the rule table this is also quite typical for process control applications. As an example, if INPUT1 is negative small (3) and INPUT2 is positive medium (6) then the rule table says change the output negative small (3). The opposite situation is also true; if INPUT1 is positive small (5) and INPUT2 is negative medium then

change the output positive small (5). Thus, as the table is being constructed, look for exactly opposite situations which will simplify the design.

I.3.1.1.6 Software Design

With the inputs and outputs, hardware interface, membership functions, and process logic determined, the only remaining step is to implement your controller using the BEARBASIC programming language. As described in Section I.3.1.1.3, the only input to the controller is from the transducer which measures the input speed. This speed is accessible using the analog capabilities of the UCP or Boss Bear. Specifically, with an analog board and the ADC statement the speed is available for manipulation in your program to generate INPUT1 and INPUT2 as shown in Section I.3.1.1.2. With these inputs available and software similar to that described in Section I.2, your controller can be implemented with all the advantages of Fuzzy Logic with minimal setup.

I.3.1.2 On-Off Control

On-Off control can be accomplished just as any process control application (See Section I.3.1.1 - Motor Speed Control - for more details) with a slight modification in the system output. Remember that a modification in the system output is not the same as a modification in the Fuzzy Logic Control output. The output of the Fuzzy Logic controller (OUTPUT from the *FUZZY* statement) can be compared with a previously determined value set by you in order to decide if the control should be On or Off. Thus, On-Off control may require use of a Divelbiss Corporation HDIO (High Density I/O) board in addition to the analog board in order to switch the output on and off.

I.4 Conclusion

Although not the solution for every application, Fuzzy Logic should be considered as a possibility in the design of every control system. To make this possible, Divelbiss Corporation has made an easy to use Fuzzy Logic statement available with its Universal Control Panel (UCP) and Boss Bear controllers. The *FUZZY* statement provides the simplest approach to the implementation of Fuzzy Logic controllers. Additionally, because the UCP and Boss Bear are general purpose programmable controllers, other applications can be handled simultaneously along with your real-time control requirements, providing maximum flexibility in system design.

Notes