Data Flow Systems

TAC PACK TCU

PROGRAMMING REFERENCE

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NOTICE

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PURPOSE OF THIS MANUAL

This manual covers the DFS BASIC-52 commands and syntax that can be used when programming the TCU. If the TCU is being used in a non-pump control application or in an application that requires control processes beyond those provided in the TCU's built-in pump control process, a customized program can be developed. Using DFS BASIC-52, the TCU can be programmed to perform a variety of automated tasks when interfaced with other DFS or Modbus-compatible telemetry equipment and field instrumentation.

It should be noted, however, that this manual does not include instructions on how to write BASIC programs. Books on programming in BASIC and QBasic can be found in local and Internet-based bookstores. There are also Web sites that provide information, including instruction and tutorials, on BASIC and QBasic. (QBasic is a version of BASIC that is similar enough to the original to be useful when learning to program the TCU.)

Note that this manual only provides information on programming the TCU. Instructions and diagrams for power, 3-phase monitor circuitry, individual I/O point, and telemetry wiring can be found in the TCU Installation and Operation Manual (part number DFS-00367-011-02).

DOWNWARD COMPATIBILITY ISSUES

When developing the TAC Pack TCU, DFS made every effort to make the TCU downward compatible with the Pump Control Unit (PCU), PCU TAC Pack, Supervisory & Control Unit (SCU), and SCU TAC Pack. There are a few important differences, however, that must be addressed when replacing one unit type with another.

Please note that the PCU, PCU TAC Pack, SCU, and SCU TAC Pack are not "upward" compatible with the TCU. DFS' Sales Department can provide assistance with ensuring that your system has appropriate replacement units on hand. Contact DFS' Sales Department (321-259-5009; sales@dataflowsys.com) for more information.

PCU and PCU TAC Pack

When using a TCU to replace a PCU that was providing power to an analog level transducer, transducer power must be acquired from pin P2-16 of the TCU. In a PCU installation, power could be acquired from pins P2-21 or P2-16. When upgrading to a TCU, the wire from P2-21 (PCU) must be moved to P2-16 (TCU). More information on wiring an analog level transducer can be found in the *TCU Installation and Operation Manual*.

SCU and SCU TAC Pack

In order for an existing SCU program to run interchangeably on both an SCU and a TCU, at least four modifications must be made to the program:

- Add code that determines if the program is running on a TCU or an SCU
- Change how the program reads the phase monitor. The TCU's C3 and C4 points (Phase AB Voltage and Phase AC Voltage, respectively) have greater ranges for the engineering and raw units values than those for the SCU. The ranges for an SCU are 151-300 VAC over a 0-255 raw units span. The ranges for a TCU are 0-350 VAC over a 0-3888 raw units span.
- Remap two I/O points wired to connector P2. In the SCU, pin P2-12 is mapped to HyperTAC II address point A11; pin P2-13 is mapped to point A12. In order for the TCU to be downwardly compatible with the Legacy PCU, and have the ability to transmit pulse input data to HyperTAC II, the TCU doesn't map these two inputs the same as the SCU. In the TCU, pin P2-12 (Legacy PCU auxiliary digital monitor input, now available for use as a digital pulse input) is mapped to HyperTAC II address point A12; pin P2-13 (Legacy PCU alarm silence switch digital monitor input) is mapped to HyperTAC II address point B7.
- Change how the menus are displayed and how keypad entries are made.
- Add a loop timer (optional) to compensate for the TCU's quicker loop time.

These differences need to be addressed in the configuration and programming of any SCU being replaced by a TCU. An Engineering Information Bulletin (EIB) with detailed information on the SCU/TCU process conversion has been released. Contact DFS' Service Department for assistance with making the required modifications.

DOCUMENT CONVENTIONS

The following conventions are used throughout this manual:

- Bulleted lists provide information, not procedural steps.
- Numbered lists provide sequential steps or hierarchal information.
- ***Bold italic*** type is used for emphasis
- *Italic* type is used to indicate text displayed on the LCD screen.
- ALL CAPITALIZED ITALIC type is used for terminal names.

ABBREVIATIONS USED IN THIS MANUAL

H-O-A – Hand-Off-Auto
I/O – Input/Output
PCU – Pump Control Unit
PLC – Programmable Logic Controller
RTU – Remote Terminal Unit
SCU – Supervisory & Control Unit
TCU – TAC Pack Telemetry Control Unit

Chapter 1: DEFINITION OF TERMS

ABBREVIATIONS

[ ]	indicates required parameter	{ }	indicates optional parameter
const	constant	cr	carriage return
expr	expression	ln num	line number
rel expr	relational expression	var	variable

ARGUMENT STACK

The argument stack is memory reserved for transferring data values from one area of the TCU to another. When working with the argument stack, it is important to note that a value placed on the argument stack by one command, must be removed with another command.

An error occurs when accessing the argument stack in the following circumstances:

- Too many items are placed on the argument stack.
- An attempt is made to remove a value from the argument stack when there is no value present (except for the Menu Statement).

Some commands that utilize the argument stack are MENU, SYSTIME, SYSCHECK, and telemetry function commands such as DGIN and DGOUT.

CARRIAGE RETURN (CR)

The carriage return represents the action of pressing the Enter or Return key on the console device or keyboard. All commands, when typed in at the command prompt (>), require a carriage return in order for the command to be executed. Throughout this manual, the carriage return is indicated by (cr).

CONTROL STACK

The control stack is external memory reserved for monitoring the foreground program operations. There are 158 bytes of external memory allocated to the control stack. This allows commands such as FOR---NEXT and GOSUB---RETURN to be executed.

- The FOR---NEXT (loop) statement requires 17 bytes of control stack memory.
- The DO---UNTIL, DO---WHILE, and GOSUB---RETURN statements each require three bytes of CONTROL STACK memory.

As a result, the maximum that DFS BASIC-52 can handle is nine nested FOR---NEXT loops (9 x 17 = 153).

A C-STACK error occurs if:

- A program attempts to use more control stack memory than is available in DFS BASIC-52.
- A RETURN is executed before a GOSUB

- A WHILE or UNTIL is executed before a DO
- A NEXT is executed before a FOR.

DFS SPECIAL (TELEMETRY)

In the DFS BASIC-52 command set, there are special function commands that most likely will not appear in other versions of Industrial BASIC. These statements, explained in detail in Chapter 2: Commands and Statements, are designated with Type: DFS Special. Some of the DFS Special commands are used solely for the telemetry interface and are designated Type: Telemetry.

EXPRESSION

An expression is a logical or mathematical formula that involves operators, constants, and variables. Expressions can be simple or quite complex. A "stand alone" variable [var] or constant [const] is also considered an expression. This document will refer to expressions with the following indicator:

[expr]

In the example below, the letter A is a variable, the 3 and 15 are constants, and the + and > signs are operators. See Chapter 3: Operators and Expressions for details on operators.

```
A+3>15
```

PI

PI is a stored constant in DFS BASICS-52. This constant is stored as 3.1415926, instead of the more common 3.1415927, to reconcile errors found in the SIN, COS, and TAN operators. The number PI/2 is needed to calculate these operators and it is desirable, for the sake of accuracy, to have the equation PI/2 + PI/2 = PI hold true. This cannot be done if the last digit is an odd number, so the last digit of PI was rounded to 6 to make these calculations more accurate.

Logical Expression

Logical expressions are expressions that involve true/false decisions (see example below). Logical expressions can be assigned to a variable just like numeric expressions and can be used to derive intermediate logical variables used in decision-making. To do this, DFS BASIC-52 assigns the following values:

- A true value is equal to 65535.
- A false value is equal to 0 (zero).

Note: When the TCU is first turned on, all variables are equal to 0 (zero).

```
TR=NOT(FA)
```

In the example above, TR and FA are variables. By using the unary operator NOT, the value of TR is now 65535 while the value of FA is still 0 (zero). This is useful when variables in a program need to be assigned to an on state (TR) or off state (FA).

Relational Expression

Relational expressions involve the following operators:

- = (equal)
- <> (not equal)
- > (greater than)
- < (less than)
- >= (greater than or equal to)
- <= (less than or equal to)

Relational expressions are used in control statements to "test" a condition (e.g., IF A<100 THEN...). Relational expressions ***always require two operands***. In this document, relational expressions are indicated as follows:

[rel expr].

Programmer's Note:	When using these variables in an IF statement, ***always*** place parenthesis around them to distinguish the variable from the rest of the statement. For example: IF (A=10); IF (B>=30)

The example below will display "Start OK" and cause the cursor to stop where it finishes printing whenever CALED and RAN are true, or when TIME is greater than 200. When CALED or RAN is false and TIME is less than 200, “Not started” will be displayed and the cursor will return to the beginning of the line on which it just wrote. See Chapter 3: Operators and Expressions for more details on relational expressions.

```
>LIST
10 START=(CALED).AND.(RAN).OR.(TIME>200)
20 IF (START) THEN  PRINT "START OK" ELSE  PRINT "NOT STARTED", CR ,
READY
>
```

RUN TRAP MODE

DFS BASIC-52 permits the user to “trap” the interpreter in Run mode. The TCU automatically enters Run mode on power up unless the 1 (one) key is held down while powering up the unit. When the 1 (one) key is held down during power up, the TCU switches into Debug mode.

SYSTEM CONTROL VALUES

The system control values include the following:

- LEN – returns the length of the program.
- FREE – returns the number of bytes of free RAM.
- MTOP – returns the last memory location assigned to BASIC.

See Chapter 3: Operators and Expressions for details on the system control values.

VARIABLES

In DFS BASIC-52, variables can be defined using up to eight letters or numbers including the underscore character. The first character, however, must ***always*** be a letter. Below are examples of valid variables.

FRED VOLTAGE1 I_I1 ARRAY(ELE_1)

In this document, variables are indicated with:

[var]

Variable names cannot contain any of DFS BASIC-52's reserved keywords (See Appendix A: Reserved Keywords for a list of reserved keywords). For example, the variables TABLE and GAIN cannot be used as variable names because TAB and IN are reserved keywords. If a reserved keyword is used when defining a variable, a BAD SYNTAX ERROR is generated.

IMPORTANT: To save time in searching for variables, DFS BASIC-52 only compares the first character, the last character, and the length of a variable name. Therefore, the following variables would be considered as the same because they each start with F, end with D, and are four characters long: FRED, FOOD, FEED, FLED. The following variables would not be considered the same: FRED, FRED1, FRED2, FEED3. Keep this in mind when defining variables to ensure that variable names don't overlap.

The example below shows how variables can be defined in DFS BASIC-52.

```
  >LIST
10    FRED=12
20    FEED=100
30    PRINT FRED

READY
>RUN

100

READY
>
```

Variables that include a one-dimensioned expression [expr] are often referred to as dimensioned or arrayed variables. Variables that are not dimensioned (as shown in the above example) are called scalar variables. The details concerning dimensioned variables are covered in the description of the DIM statement in Chapter 2: Commands and Statements.

DFS BASIC-52 allocates variables in a "static" manner. Each time a variable is used, BASIC allocates a portion of memory (8 bytes) specifically for that variable. This memory cannot be "de-allocated" on a

variable-by-variable basis. For example, if you execute the statement Q=3, you cannot later tell BASIC that the variable Q no longer exists in order to “free up" the 8 bytes of memory that belong to Q. The only way to clear memory allocated to variables is to execute a CLEAR statement. The CLEAR statement "frees" all memory allocated to variables except memory allocated for STRING variables.

Programmer's Note:	Relative to a dimensioned variable, it takes DFS BASIC-52 a lot less time to find a scalar variable. That's because there is no expression to evaluate in a scalar variable. If you want to make a program run as fast as possible, use dimensioned variables only when necessary. Use scalar for intermediate variables, then assign the result to a dimensioned variable.

Notes

EPROM COMMANDS

The sections that follow provide information on commands that can be used to manipulate programs stored in EPROM (Erasable Programmable Read Only Memory). Note that the TCU must be in Debug, or Program, mode in order to execute EPROM commands.

EPROG Command

Format: EPROG (cr)

The EPROG command copies the program currently stored in RAM into the next available memory location of the onboard write-protected memory.

After EPROG is executed, DFS BASIC-52 displays the number of the EPROM file that the program will occupy (1-8). The CHECKSUM is provided to verify proper programming.

In the example below, the program placed in the write-protected memory is the first program stored (located in the ROM 1 location).

Example:

```
>LIST
10      FOR X=1 TO 10
20      PRINT X
30      NEXT X
READY

>ERASE
>EPROG
1 (EECHECKSUM=00C8H)

>ROM

READY
>LIST
10      FOR X=1 TO 10
20      PRINT X
30      NEXT X

READY
>
```

ERASE Command

Format: ERASE[integer] (cr)

The ERASE command erases all EPROM programs from the EPROM file. This is normally done just before programming the EPROM with the EPROG command. The optional integer is used to indicate where erasing is to start. For example, if you wanted to erase all programs starting at the ROM 2 location, you would enter ERASE 2. Note that if there are three programs resident in the EPROM, you

cannot erase program 2 without also erasing program 3. However, program 1 would remain in the EPROM. If no integer is entered, the entire EPROM (all eight locations) is erased.

This command should not be confused with the NEW command. The NEW command clears the program information out of the RAM location, not the ROM location.

RAM Command

Format: RAM (cr)

When RAM (short for Random Access Memory) is entered, DFS BASIC-52 makes RAM the active memory location. A program located in RAM may be "LISTed," RUN, or edited by the user. This is considered the Debug mode of operation and is the command interpreter mode that users interact with most while developing a program. DFS BASIC-52 starts in this mode when the TCU's 1 (one) key is pressed and held during power up.

ROM Command

Format: ROM[integer] (cr)

When ROM[integer] is entered, DFS BASIC-52 makes the selected ROM (short for Read Only Memory) in the write-protected memory the active memory location. A program located in a ROM location can be LISTed or RUN. If no integer is typed after the ROM command, DFS BASIC-52 defaults to the ROM 1 location. Since the programs are stored sequentially in write-protected memory, the integer following the ROM command is used to indicate which program is to be run or listed. If you attempt to select a program that does not exist (for example, you type ROM8 and only 6 programs are stored in the write-protected memory), the message ERROR: PROM MODE is displayed.

DFS BASIC-52 does ***not*** transfer the program from EPROM to RAM when ROM mode is selected. As a result, you cannot edit a program in ROM mode. If you attempt to edit a program in ROM mode by typing in a line number, the message ERROR: PROM MODE is displayed. The XFER command, discussed in the next section, allows you to transfer a program from EPROM to RAM for editing purposes.

Since the ROM command does not transfer a program to RAM, it is possible to have different programs in ROM and RAM simultaneously. The user can "flip" back and forth between the two modes at any time. Another added benefit of not transferring a program to RAM is that all of the RAM memory can be used for variable storage when the program is stored in EPROM. The system control values MTOP and FREE always refer to RAM not EPROM. System control values are discussed in Chapter 3: Operators and Expressions on page 81.

XFER Command

Format: XFER (cr)

The XFER command transfers the currently selected program from ROM to RAM and then selects RAM mode. After the XFER command is executed, you may edit the program in the same manner that any RAM program may be edited. If XFER is typed while DFS BASIC-52 is in RAM mode, the program currently stored in RAM is transferred back into RAM and RAM mode is selected (this action produces no net result).

BASIC COMMANDS

(Ctrl) C Command

From time to time, it is possible that a programmer writes a portion of code that leaves the program caught in an endless loop. If this occurs or if the programmer needs to stop the program for debugging purposes, the (Ctrl) C command can be issued from the terminal to stop the program. When the TCU is in Debug mode, the program stops, and the command prompt (>) appears. However, if the TCU is in RUN mode, the (Ctrl) C command merely restarts the program stored in the ROM 1 location.

When the TCU is in Debug mode, the (Ctrl) C command will also stop the program from listing after the LIST command has been issued.

When using the CALL command, it is necessary to enter a sequence of three (Ctrl) C commands to break out of the routine and stop or restart the program.

CONT Command

Format: CONT(cr)

If a program is stopped using (Ctrl) C or by executing a STOP statement, it can be resumed by typing CONT(cr). Between stopping and restarting the program, you can display or change the values of variables. However, you ***cannot*** issue the CONT command if:

- The program is modified (by typing or retyping a line number) while the program is stopped.
- The program is stopped because of an error.
- An error occurs due to a mistyped command while the program is stopped.

The example below shows how the CONT command can be used to resume program execution after (Ctrl) C has been used to stop the program.

```
>LIST
10      FOR X=1 TO 100
20      PRINT X
30      NEXT X

READY
>RUN12  (Ctrl-C typed at console)
STOP - IN LINE  20

READY
>PRINT X
3

>X=25
>CONT
25
26
27
28
```

LIST Command

Format: LIST(cr)

The LIST(cr) command prints the program to the console device. Note that the list command "formats" the program in an easy to read manner. Spaces are inserted after the line number, and before and after statements. This feature is designed to aid in the debugging of DFS BASIC-52 programs. The "listing" of a program may be terminated at anytime by using the (Ctrl) C command from the console device.

Variations

Two variations of LIST are possible with DFS BASIC-52.

- LIST [1n num](cr) – Prints the program from the designated line number (integer) to the end of the program.
- LIST [1n num]-[1n num](cr) – Prints the program from the first line number (integer) to the second line number (integer). The two line numbers must be separated by a hyphen (-).

The example below illustrates how both variations of the LIST command can be used.

```
>LIST
10      PRINT "LOOP PROGRAM"
20      FOR X=1 TO 3
30      PRINT X
40      NEXT X
50      END

READY
>LIST 30
30      PRINT X
40      NEXT X
50      END

READY
>LIST 20-40
20      FOR X=1 TO 3
30      PRINT X
40      NEXT X

READY
>
```

NEW Command

Format: NEW(cr)

When NEW(cr) is entered, DFS BASIC-52 deletes the program currently stored in RAM. This command also:

- Resets all scalar and array variables to 0 (zero).
- Clears all string variables.
- Clears all BASIC evoked interrupts.

Note that the real time clock, memory allocated for strings, and the internal stack pointer value (location 3EH) are ***not*** affected. In general, NEW (cr) is used to erase a program and all variables.

This command should not be confused with the ERASE command. The ERASE command clears the program information out of the ROM location(s), not the RAM location.

NULL Command

Format: NULL[integer](cr)

The NULL command determines how many null characters (00H) DFS BASIC-52 will output after a carriage return. After initialization, NULL = 0. The NULL command was more important in the past when a "pure" mechanical printer was the most common I/O device. Most modern printers contain some kind of RAM buffer that virtually eliminates the need to output null characters after a carriage return.

Note: The NULL count used by DFS BASIC-52 is stored in internal RAM location 21 (15H). The NULL value can be changed dynamically in a program by using a DBY(21)=[expr] statement. The [expr] can be any value between 0 and 255 (0FFH) inclusive.

RUN Command

Format: RUN(cr)

The RUN command and GOTO statement are the only methods available in Command mode for executing a program located in RAM or ROM, and placing the DFS BASIC-52 interpreter in Run mode.

After RUN(cr) is typed:

1. All variables are set equal to zero.
2. All BASIC evoked interrupts are cleared.
3. Program execution begins with the first line number of the selected program. Program execution may be terminated at any time by typing a (Ctrl) C on the console device.

Variations

Unlike some Basic interpreters, DFS BASIC-52 does not permit line numbers to follow the RUN command (for example, RUN 100). Execution always begins with the first line number. To obtain the same functionality as the RUN[1n num] command, use the GOTO[1n num] statement in the direct mode (see the GOTO statement in Chapter 2: Commands and Statements).

You can also use the RROM[integer] command, which instructs the interpreter to run the program in the ROM location specified by the integer (only the values 1 through 8 may be used). See the RROM statement in Chapter 2: Commands and Statements.

Correct use of the RUN command is shown in the example below.

```
>LIST
10     FOR X=1 TO 3
20     PRINT X
30     NEXT X

READY
```

(continued on next page…)

```
>RUN

 1
 2
 3

READY
>
```

BASIC STATEMENTS

CALL Statement

Format: CALL [integer]

Mode: Command; Run

Type: Control

The CALL [integer] statement is used to call certain debug assembly language programs. These routines are generally used by the programmer while troubleshooting the program. The valid integer values are:

0	Causes the TCU to do a power on reset, which • Clears all variables. • De-allocates memory reserved for strings. • Clears the program stored in RAM if the program does not include the '0 REM DEBUG' line of code.
1	Causes the TCU to do a power on reset, which: • Clears all variables. • De-allocates memory reserved for strings. • Clears the program stored in RAM if the program does not include the '0 REM DEBUG' line of code.
2	Switches the display to monitor the TCU to RIM communications.
3	Switches the display to watch the PRINT statements executed in the TCU program.
4	Logs fault code on stack
5	Adjusts LCD contrast
7	Clear fault code table

When the values 2 is used during program execution, all text sent to the display by the PRINT statement will be suspended while bus communication messages to and from the TCU are displayed. To view the print statements, a CALL3 command must first be executed.

To break out of the CALL2 mode entered at the command line, enter the (Ctrl) C command three times.

Below is an example of the CALL0 statement.

```
READY
>CALL0

 )-----------[ DFS Programmable Logical Controller V5.1 03/06/97 ]-----------(

READY
>
```

CHKTIMER Statement

Format: CHKTIMER [expr]

Mode: Command; Run

Type: Input/Output - DFS Special

This command gets the current value (in seconds) of a countdown timer. When the CHKTIMER [expr] command is executed, the value of the timer is pushed onto the argument stack. The value must then be "POPped" (see the POP statement, page 39) off the argument stack and assigned to a variable. There can be 127 different count down timers.

See SETIMER command for additional information and examples.

CLEAR Statement

Format: CLEAR

Mode: Command; Run

Type: Control

The CLEAR statement sets all variables equal to zero and resets all BASIC evoked interrupts and stacks. After the CLEAR statement is executed, error trapping via the ONERR statement will not occur until an ONERR[integer] statement is executed. CLEAR does ***not*** reset timers set with the SETIMER statement or free up memory allocated for strings with the STRING statement. It is ***not*** necessary to enter the STRING [expr], [expr] statement to re-allocate memory for strings after the CLEAR statement is executed. However, a PUSH 0 : SETIMER # line of code would be necessary to reset the timers. In general, CLEAR is simply used to "erase" all variables.

CLEARS Statement

Format: CLEARS

Mode: Command; Run

Type: Control

The CLEARS statement resets all of DFS BASIC-52's stacks. The control stack and argument stack are reset to their initialization value, 254 (0FFH) and 510 (1FEH) respectively. The internal stack (the 8052AH's stack pointer, special function register-SP) is loaded with the value that is in internal RAM location 62 (3EH). This statement can be used to "purge" the stack should an error occur in a subroutine. In addition, this statement can be used to provide a "special" exit from a FOR-NEXT, DO-WHILE, or DO-UNTIL loop.

An example of the CLEARS statement is provided below.

```
>LIST
5       STRING 3,1
10      CLEAR  :  DO
15      PRINT "MULTIPLICATION TEST.",
16      PRINT "  YOU HAVE 5 SECONDS FOR EACH PROBLEM.  BEGIN!!!"
20      FOR T=1 TO 3
30      N=INT(RND*10) : A=N*T
40      PRINT "WHAT IS",N,"*",T,
50      PUSH 5 :  SETIMER 1 :  INPUT R
60      CHKTIMER 1 :  POP TMR1
70      IF (R=A).AND.(TMR1>0) THEN  PRINT "THAT'S CORRECT!" : COR=COR+1
80      IF (R<>A).AND.(TMR1>0) THEN  PRINT "THAT'S INCORRECT."
90      IF (TMR1=0) THEN  PRINT "YOU WEREN'T QUICK ENOUGH!"
100     NEXT T
105     PRINT "YOU ANSWERED ",COR," PROBLEMS OUT OF ",T-1," CORRECTLY."
110     INPUT "DO YOU WANT TO TRY AGAIN (Y,N)",$(0)
120     AGAIN=(ASC($(0),1)=89)
130     IF NOT(AGAIN) THEN  CLEAR S
140     WHILE (AGAIN)

READY
>
```

Programmer's Note: When the CLEARS statement is LISTed, it will appear as CLEAR S.

In the example above, if you select any character other than a capital Y, the TCU program delivers the following output.

```
DO YOU WANT TO TRY AGAIN (Y,N)y
ERROR: C-STACK - IN LINE  140
140    WHILE (AGAIN)
----------------------X
READY
>
```

This error occurred because in line 130, the variable AGAIN is false and the stack is cleared with the CLEARS statement. Therefore the stack pointer linking the WHILE statement to the DO statement was reset (cleared).

DATA, READ, RESTORE Statements

Format: DATA -- READ -- RESTORE

Mode: Run

Type: Assign

DATA	The DATA statement specifies expressions that may be retrieved by a READ statement. If you use multiple expressions per line, you ***must*** separate them with a comma.
READ	The READ statement retrieves the expressions that are specified in the DATA statement and assigns the value of the expression to the variable in the READ statement. The READ statement ***must always*** be followed by one or more variables. If more than one variable follows a READ statement, they ***must*** be separated by a comma.
RESTORE	The RESTORE statement "resets" the internal read pointer back to the beginning of the first data line so that the data may be read again.

Below is an example using the DATA, READ, and RESTORE statements.

```
>LIST
10     FOR A=1 TO 3
20     READ B,C
30     PRINT B,C
40     NEXT A
50     RESTORE
60     READ A,B
70     PRINT A,B
80     DATA 10,20,10/2,20/2,SIN(PI),COS(PI)

READY
>RUN

10  20
5  10
0 -1
10  20
```

Every time a READ statement is encountered, the next consecutive expression in the DATA statement is evaluated and assigned to the variable in the READ statement. DATA statements can be placed anywhere within a program; they will ***not*** be executed nor will they cause an error. DATA statements are considered to be chained together, so that they appear to be one large DATA statement. If at anytime all the DATA has been read and another READ statement is executed, the program is terminated and the message ERROR: NO DATA - IN LINE XX is printed to the console device.

DIM Statement

Format: DIM (Array Var(integer))

Mode: Command; Run

Type: Assignment

The DIM statement reserves storage for matrices (Note that the storage area is first assumed to be zero). Matrices in DFS BASIC 52 can have only one dimension and the size of the dimensioned array ***cannot*** exceed 255 elements [for example, DIM (254)]. Once a variable is dimensioned in a program, it ***cannot*** be re-dimensioned. An attempt to re-dimension an array will cause an ARRAY SIZE error. If an arrayed variable that has ***not*** been dimensioned by the DIM statement is used, BASIC will assign a default value of 10 to the array size. All arrays are set equal to zero when the RUN command, NEW command, or CLEAR statement is executed.

The number of bytes allocated for an array is six times the array size plus one. For example, the line of code DIM A(99) would require 606 bytes of storage [(100+1)*6]. Remember that the first array variable would be A(0) and the last one would be A(99) after executing DIM A(99) to create a 100-element array. The size of a dimensioned array is usually limited by memory size.

Variations

More than one variable can be dimensioned by a single DIM statement [for example, DIM A(10), B(15), A1(20)]. In addition, the integer designating the number of array variables can be represented by a variable [for example, DIM A(NUM), B(NUM+1)], where NUM is a valid array size integer.

The example below shows the error that results when you attempt to re-dimension an array.

```
>LIST
10    A(5)=23 :  REM BASIC ASSIGNS DEFAULT OF 10 TO ARRAY SIZE HERE
20     DIM A(5) :  REM ARRAY CANNOT BE REDIMENSIONED

READY
>RUN

ERROR: ARRAY SIZE - IN LINE  20

20     DIM A(5) :  REM ARRAY CANNOT BE REDIMENSIONED
---------------X
READY
>
```

In the example below, the array variable PMP is dimensioned to 6, which allows it to have seven elements (0 to 6).

```
>LIST
10    DIM PMP(6)
20    FOR X = 0 TO 6
22    PMP(X) = X+1
```

(continued on next page…)

```
24     PRINT PMP(X),
30    NEXT X

READY
>RUN

1  2  3  4  5  6  7
```

DO, UNTIL Statements

Format: DO -- UNTIL [rel expr]

Mode: Run

Type: Control

The DO -- UNTIL instruction provides a means of "loop control" within a DFS BASIC-52 program. The operation of this statement is similar to DO -- WHILE except that all statements between the DO and the UNTIL will be executed until the relational expression following the UNTIL statement is true. DO -- UNTIL and DO -- WHILE statements can be nested.

The first example below illustrates a simple DO -- UNTIL; the second example uses a nested DO -- UNTIL.

Simple DO -- UNTIL

```
>LIST
5      REM SIMPLE DO -- UNTIL
10    A=0
20     DO
30    A=A+1
40     PRINT A
50     UNTIL A=4
60     PRINT "DONE"

READY
>RUN

 1
 2
 3
 4
DONE
```

Nested DO -- UNTIL

```
>LIST
5       REM NESTED DO -- UNTIL
10      A=0 : B=0
20      DO  : A=A+1 :  DO  : B=B+1
25      PRINT A,B,A*B
30      UNTIL B=3
40      B=0
50      UNTIL A=2

READY
>RUN

 1  1  1
 1  2  2
 1  3  3
 2  1  2
 2  2  4
 2  3  6
```

DO, WHILE Statements

Format: DO -- WHILE [rel expr]

Mode: Run

Type: Control

The DO -- WHILE instruction provides a means of "loop control" within a DFS BASIC-52 program. The operation of this statement is similar to DO -- UNTIL except that all statements between DO and WHILE will be executed as long as the relational expression following the WHILE statement is true. DO -- WHILE and DO -- UNTIL statements can be nested.

Simple DO -- WHILE

```
>LIST
5       REM SIMPLE DO -- WHILE
10      DO
20     A=A+1
30      PRINT A
40      WHILE A<4
50      PRINT "DONE"

READY
>RUN
```

(continued on next page…)

```
 1
 2
 3
 4
DONE
```

Nested DO -- WHILE

```
>LIST
5      REM NESTED DO -- WHILE AND DO -- UNTIL
10     DO  : A=A+1 :  DO  : B=B+1
20     PRINT A,B,A*B
30     WHILE B<3
40    B=0
50     UNTIL A=2

READY
>RUN

 1  1  1
 1  2  2
 1  3  3
 2  1  2
 2  2  4
 2  3  6
```

END Statement

Format: END

Mode: Run

Type: Control

The END statement terminates program execution. When the END statement is used to terminate the program, the continue command (CONT) cannot be used to resume the program. If you attempt to issue the CONT command after an END statement, a CAN'T CONTINUE error will be printed to the console. The last statement in a DFS BASIC-52 program will automatically terminate program execution if no END statement is used.

Automatically terminated program (no END statement used)

```
>LIST
5      REM LAST STATEMENT TERMINATION
10    FOR N=1 TO 3
20    PRINT N

READY
>RUN

 1
 2
 3
```

Program terminated with END statement

```
>LIST
5      REM END STATEMENT TERMINATION
10     FOR N=1 TO 3
20     GOSUB 100
30     NEXT N
40    END
100    PRINT N : RETURN

READY
>RUN

 1
 2
 3
```

FOR, TO, NEXT Statements

Format: FOR -- TO -- {STEP} -- NEXT

Mode: Command; Run

Type: Control

The FOR -- TO -- {STEP} -- NEXT statements are used to set up and control loops.

In the examples below:

- The variable "A" represents the name of the index or loop counter.
- The value of "B" is the starting value of the index.
- The value of "C" is the limit value of the index.
- The value of "D" is the increment to the index.

STEP is an optional statement. If the STEP statement and the value "D" are omitted, the increment value defaults to 1 (one). The NEXT statement causes the value of "D" to be added to the index. The index is then compared to the value of "C," which is the limit. If the index is less than or equal to the limit, control will be transferred back to the statement after the FOR statement. Stepping " backwards" (for example, FOR X = 100 TO 1 STEP-1) is permitted in DFS BASIC-52.

FOR -- TO -- {STEP} -- NEXT

```
>LIST
5     B=0 : C=10 : D=2
10     FOR A=B TO C STEP D
20     PRINT A,
30     NEXT A

READY
>RUN

 0  2  4  6  8  10
```

FOR -- TO -- NEXT (STEP omitted)

```
>LIST
5     B=0 : C=10
10     FOR A=B TO C
20     PRINT A,
30     NEXT A

READY
>RUN

 0  1  2  3  4  5  6  7  8  9  10
```

FOR -- TO -- {STEP (backwards)} -- NEXT

```
>LIST
10     FOR X=4 TO 1 STEP -1
20     PRINT X,
30     NEXT X

READY
>RUN

 4  3  2  1
```

In DFS BASIC-52, it is possible to execute the FOR -TO -{STEP}-NEXT statement in Command mode. This makes it possible for the user to do things like display regions of memory by writing a short program right at the command prompt without affecting the written program located in the RAM or ROM.

```
>FOR V=0 TO 9 : LD@(5005H+V*6) : POP X : PRINT X, : NEXT
 300  300  120  90  2378  3224  30  1  0  3
>
```

GOSUB, RETURN Statements

Format: GOSUB [ln num] -- RETURN

Mode: Run

Type: Control

The GOSUB statement causes DFS BASIC-52 to transfer control of the program directly to the line number [ln num] following GOSUB. Additionally, GOSUB saves the location of the statement following GOSUB onto the control stack.

RETURN is used to "return" control to the statement following the most recently executed GOSUB statement. The GOSUB statement can call another subroutine with another GOSUB statement.

Simple subroutine

```
>LIST
10     FOR X=1 TO 5
20     GOSUB 100
```

(continued on next page…)

```
30     NEXT X
40     END
```

```
100    PRINT X,
110    RETURN

READY
>RUN

 1  2  3  4  5
READY
>
```

Nested subroutine

```
>LIST
10     FOR X=1 TO 5
20     GOSUB 100
30     NEXT X
40     END
100    PRINT X,
110    GOSUB 200
120    RETURN
200    PRINT 2*X
210    RETURN

READY
>RUN

 1  2
 2  4
 3  6
 4  8
 5  10
```

If too many GOSUB statements are used without executing a RETURN statement, an error will occur as shown below.

```
>LIST
10     GOSUB 1000
20     PRINT X,
30    X=X+1
40     GOTO 10
1000   REM line 1000
1010   GOTO 20
1020   RETURN

READY
>RUN

                                                    (continued on next page…)
```

```
 0  1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20
 21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39
 40  41  42  43  44  45  46  47  48  49  50  51

ERROR: C-STACK - IN LINE  20

20     PRINT X,
-------------X
READY
>
```

GOTO Statement

Format: GOTO [ln num]

Mode: Command; Run

Type: Control

The GOTO statement causes BASIC to transfer control directly to the line number [ln num] following the GOTO statement. If a nonexistent line number is entered after GOTO, an INVALID LINE NUMBER error will be returned.

```
>LIST
10     GOTO 100
20     PRINT "THIS LINE SKIPPED"
100    PRINT "LINE 100"

READY
>RUN

LINE 100

READY
>
```

Unlike RUN, executing GOTO in Command mode does ***not*** clear variable storage space or interrupts unless GOTO is executed ***after*** a line has been edited. Executing GOTO after editing a line causes DFS BASIC-52 to clear the variable storage space and all BASIC evoked interrupts. This is necessary because the variable storage and the BASIC program reside in the same RAM memory. Be cautious when using GOTO, because editing a program can destroy variables.

The GOTO statement may also be used in conjunction with the ON statement to produce an ON [expr] GOTO[ln num], [ln num],...[ln num] line of code.

IF, THEN, ELSE STATEMENTS

Format: IF -- THEN -- ELSE

Mode: Run

Type: Control

The IF statement is used to set up a conditional test. The generalized form of the IF--THEN--ELSE statement is as follows:

[ln num] IF [rel expr] THEN [rel expr] or [valid statement] ELSE [rel expr] or [valid statement].

When line 100 is executed in the example below:

- If A is equal to 100, the program returns to the statement following the GOSUB that called this portion of the program.
- If A does not equal 100, A is assigned a value of A + 1.

You can also add multiple commands after each command. See line 110 in the example below.

```
>LIST
100     IF (A=100) THEN RETURN ELSE A=A+1
110     IF (A=10) THEN B=20:C=30 ELSE B=50:C=60
```

GOTO is optional when IF is used to transfer control to different line numbers. The following examples would yield the same results.

```
>LIST
20     IF (INT (A)< 10) THEN GOTO 100 ELSE GOTO 200
30     IF (INT (A)< 10) THEN 100 ELSE 200
```

Additionally, the THEN statement can be replaced by any valid DFS BASIC-52 statement, as shown below.

```
>LIST
40     IF (A<>10) THEN PRINT A ELSE 10
50     IF (A<>10) PRINT A ELSE 10
```

The ELSE statement may also be omitted. If ELSE is omitted, control passes to the next statement. In the example below:

- If A is greater than 10, control is passed to line number 40.
- If A does not equal 10, line number 30 is executed.

```
>LIST
10     TEST_OK=(A>10)
20     IF  (TEST_OK) THEN 40
30     PRINT A
```

Programmer's Note:	Notice the use of the logical variable "TEST_OK" in the example above. When using these variables in an IF statement, always place parenthesis around them to distinguish the variable from the rest of the statement. It is good practice to always place parenthesis around the [rel expr] in an IF statement.

INPUT Statement

Format: INPUT

Mode: Run

Type: Input/Output

The INPUT statement allows users to enter data from the console during program execution. This is not often used for process control, because it relies on an operator to enter values in order for the process routine to actually run.

One or more variables can be assigned data with a single INPUT statement, but they must be separated by a comma (for example, INPUT A,B). The INPUT statement causes the printing of a question mark (?) on the console device as a prompt to the operator to input data. If the operator does not enter enough data, DFS BASIC-52 outputs a TRY AGAIN message to the console device. The INPUT statement can be written so that a descriptive prompt is printed to tell the user what to type. The message to be printed is placed in quotes after the INPUT statement. If a comma appears before the first variable on the input list, the question mark prompt character will not be displayed.

Strings can also be assigned with an INPUT statement. Because strings are always terminated with a carriage return (cr), DFS BASIC-52 will prompt the user with a question mark if more than one string input is requested with a single INPUT statement.

Input statement requiring more data (TRY AGAIN generated)

```
>LIST
5      STRING 11,4
10     INPUT A,B
20     INPUT $(1)
30     PRINT $(1),B,A
READY
>RUN

?5

TRY AGAIN

?5,8

?TEST
TEST 8  5
```

Input statement with descriptive prompt

```
>LIST
5      STRING 11,4
10     INPUT "ENTER A 4 LETTER WORD: ",$(1),$(0)
20     INPUT ,B,A
30     PRINT $(0),$(1),B,A

READY
>RUN

ENTER A 4 LETTER WORD: TEST
?ZERO
25,965
ZERO TEST 25  965
```

Input statement using strings

```
>LIST
10     STRING 100,10
20     INPUT "NAME(CR), AGE - ",$(1),A
30     PRINT "HELLO ",$(1),", YOU ARE ",A, "YEARS OLD."

READY
>RUN

NAME(CR), AGE - FRED
?15
HELLO FRED, YOU ARE 15 YEARS OLD.
```

LD@ Statement

Format: LD@ [expr]

Mode: Command; Run

Type: Input/Output – DFS Special

DFS BASIC-52 reserves 1008 bytes of non-volatile memory starting at location 5000H. This memory is reserved for the purpose of storing and retrieving floating point set point variables in battery backed-up (non-volatile) memory. When the RTU is powered down for any reason, previously assigned set points are allowed to recover to their last set value. Up to 168 basic variables (six bytes per variable) can be stored in non-volatile memory using the ST@ command (discussed on page 49) and retrieved using LD@. A table listing all of the memory locations is provided in Appendix B: Free External Memory Storage Map.

LD@ allows the user to retrieve floating-point numbers that were saved with ST@. The expression [expr] following LD@ specifies where the number is stored. After executing LD@, the number is placed on the argument stack. The POP command must be used to retrieve the value from the argument stack and assign it to a variable.

Programmer's Note:	ST@ and LD@ statements point to the least significant byte of the stored number in accordance with the floating-point format. Hence, ST@ (5005H) would save the number in locations 5000H, 5001H… 5005H.

```
>LIST
10     REM RETRIEVING A TEN ELEMENT ARRAY
100    FOR X=0 TO 9
110    LD@ 5005H+6*X :  POP SETPNT(X)
120    NEXT X

READY
>RUN

READY
>
```

Memory Image Updating via PLC Editor

Values can also be transferred to and from the TCU's non-volatile memory locations using PLC Editor. This is an advanced feature used to send set point variables to the TCU over a radio link. At times, the amount of real and virtual I/O exceeds the 15-module capacity of the single RTU. With the Memory Image Updating feature, additional set points can be communicated between the central computer and the TCU.

Note, however, that memory image updating will not work with the TCU if it is connected to an RTU that is operating with a PLC. This is due to both the PLC and TCU responding to module "Q."

PLC Editor is a separate utility that works in conjunction with the HyperTAC II software. Refer to the onscreen help for PLC Editor for information on using this application.

Floating Point Format

BASIC-52 stores all floating-point numbers in a normalized packed Binary Coded Decimal (BCD) format with an offset binary exponent requiring six bytes of storage. In the following explanation, the value of PI (3.1415926) is used as an example and is stored at memory location X.

If we were to save the value of PI into memory location 5005H using the ST@ command (where X would now equal 5005H), the line of code would read:

PUSH PI : ST@5005H

Byte 5005H would contain the Exponent value (81H), and byte 5000H would contain the most significant two digits (31H).

Location	Value	Description
X	81H	Exponent 81H = 10**1; 82H = 10**2; 83H = 10**3; etc. 80H = 10**0; 7FH = 10**-1; 7EH = 10**-2; etc. The number ZERO is represented with a ZERO exponent.
X-1	00H	Sign Bit 00H = Positive; 01H = Negative

		Other bits are used as temporary positions only during a calculation
X-2	26H	Least significant two digits
X-3	59H	Next least significant two digits
X-4	41H	Next most significant two digits
X-5	31H	Most significant two digits

LET Statement

Format: LET

Mode: Command; Run

Type: Assignment

The LET statement is used to assign a variable to the value of an expression. The generalized form of LET is:

LET[var] = [expr]

Note that the = sign used in the LET statement is not an equality operator, but rather a "replacement" operator. The statement should be read as:

A is replaced by A plus one

The word LET is always optional, (that is, LET A = 2 is the same as A = 2). When LET is omitted, the LET statement is called an IMPLIED LET. This manual uses the word LET to refer to both the LET statement and the IMPLIED LET statement.

The LET statement is also used to assign a string variable, (for example, LET $(1)="THIS IS A STRING"). Before strings can be assigned, the STRING statement ***must*** be executed. Failure to do so will generate a MEMORY ALLOCATION ERROR.

Special function operators can also be assigned by the LET statement, [for example, LET XBY(2000H)=5AH, or LET DBY(25)=XBY(1000)].

LET Statement

```
>LIST
10     LET A = 10*SIN(B)/100
20     LET A = A + 1

READY
>
```

IMPLIED LET Statement

```
>LIST
10     A = 10*SIN(B)/100
20     A = A + 1

READY
```

```
>
```

MENU Statement

The MENU statement is used to manipulate the TCU's LCD in a background mode. Because the BASIC routine may take seconds to update the display, the MENU statement allows menu pages to be predefined and the display to be updated from a background keyboard routine. MENU has various command line parameters that cover multiple functions.

You can define up to 16 menus. Each menu is one full 4x20 LCD screen. You can envision this as a stack of 16 pages each with four lines of text. Each line can be up to 20 characters long.

MENU

Format: MENU

Mode: Command; Run

Type: Input/Output; DFS Special

The MENU statement, when used without additional parameters, performs dual functions. It may:

- Pass a value off the argument stack to the LCD control routine.
- Take the value of the active menu item from the LCD control routine and place it on the argument stack.

If the MENU statement is used without additional parameters, but is preceded by the PUSH [n] statement (where n is between 1 and 16), it forces the nth menu page to be displayed on the LCD (see PUSH statement, page 45). If a value outside the 1 to 16 range is on the top of the argument stack when the MENU statement is executed, an INVALID MENU OPTION error appears on the console device and program execution is stopped or restarted.

If the MENU statement is used without additional parameters and no value has been "PUSHed," the menu page and the line currently displayed on the LCD are placed on the argument stack. The POP statement (see page 39) must be used immediately following the MENU statement in order to retrieve the menu page and line from the argument stack.

In the example below, three menu items (0, 1, and 2) are defined. When the program is executed, menu item 1 "ALARMS" is displayed on the LCD.

Menu statement (proceeded by PUSH)

```
>LIST
5      SYSTIME  :  POP SC,MN,HR,DY,DT,MO,YR
10     MENU (1,1)="      Time -",HR,":",MN
12     MENU (1,2)="ALARMS"
14     MENU (1,3)="CONFIGURATION"
20     PUSH 1 :  MENU
30     MENU ON

READY
>RUN

READY
```

```
>
```

This example shows how the Menu statement is used to read the page and line that have been selected on the TCU's LCD.

Menu statement (followed by POP)

```
2016 Menu On
2018 Menu: pop Pg,Ln   : REM Get page and line selected on LCD
```

MENU ON

Format: MENU ON

Mode: Command; Run

Type: Control; DFS Special

Using the ON parameter with the MENU statement enables the background LCD control routine to display menu items defined and selected by the foreground program. While the MENU is ON, the following have no affect:

- The PRINT@ statement
- The LED DS4, which is the LCD backlight

Refer to the examples for the other MENU statements to see how MENU ON can be used in a DFS BASIC-52 program.

MENU OFF

Format: MENU OFF

Mode: Command; Run

Type: Control; DFS Special

Using the OFF parameter with the MENU statement causes menu display operations to be suspended. While the MENU is OFF:

- The PRINT@ statement can be used to print up to 20 characters to the LCD at a time.
- The LED DS4, which is the LCD backlight, may also be turned on and off from the program using the DGOUT statement (refer to the DGOUT statement for specifics on LED controls).

In this example, the menu display is turned off and the TCU's splash screen is displayed.

```
REM Splash:
6814 Menu Off
6816 Print Using(0),                  : REM Clear screen
6818 For I=1 to 4:print@ " ":next I
6820 Print@"   Pump Controller"       : REM display splash screen
6822 Print@" "
6824 Print@"   Proc ID=",PgID : ReM with program ID
6826 Print@" Version=",PgVer          : ReM and version
6828 Return
```

MENU CLR

Format: MENU ON

Mode: Command; Run

Type: Control; DFS Special

Using the CLR parameter with the MENU statement, instructs the LCD control routine to clear the active menu list. If the MENU is still ON, the display defaults to MENU 1.

The example below shows the appropriate sequence of statements to use to prevent the menu items from flashing on and off or changing erratically while the MENU is being turned ON and OFF, CLRed, and reset.

```
> MENU (1,1)=“TEST MENU 0”
> MENU (2,1)=“TEST MENU 1”
> MENU (3,1)=“TEST MENU 2”
> MENU ON              : REM USING THE ARROW KEYS, SCROLL THROUGH TO ‘TEST MENU 1’
> MENU OFF             : REM ‘TEST MENU 1’ WILL REMAIN VISIBLE ON THE LCD
> MENU (4,1)=“TEST OVER 3”
> MENU ON              : REM ‘TEST MENU 0’ WILL BE DISPLAYED FOLLOWED BY MENU ITEMS 1, 2, 3
```

MENU (define menu pages)

Format: MENU (page, line) = expr

Mode: Command; Run

Type: Assignment; DFS Special

Parameters:

page := integer 1-16 indicating menu page to be assigned

line := integer 1-4 indicating the line on the above page to be assigned

expr := combinations of constants and variables of strings and/or numerical values

This variation of the MENU statement is used to define the menu pages. The list of expressions (expr) to the right of the equals sign can be any valid expressions described in the PRINT command. The page and line variables specify which page and line to modify. Once any line on a page has been defined, that page

is accessible via the TCU's left and right arrow keys until the MENU CLR command is executed. Pressing the right arrow key displays the next menu page. Pressing the left arrow key displays the previous menu page.

In the example below, two menu pages are set up with two lines on each page. Menu page 1, line 2 & 3, and menu page 2, line 2 & 3, are defined. When the program is executed, menu page 1 is displayed on the LCD.

```
5       SYSTIME   :   POP SC,MN,HR,DY,DT,MO,YR
10      MENU (1,2)="   TCU TEST PROGRAM"
20      MENU (1,3)="      Time -",HR,":",MN
30      MENU (2,2)="               ALARMS"
40      MENU (2,3)="       CONFIGURATION"
50      PUSH 1 :  MENU
60      MENU ON
```

MENU INPUT

Format: MENU INPUT [$(]default[)], lolimit, hilimit

Mode: Command; Run

Type: Input; DFS Special

Parameters:

default := the default starting value of the input

lolimit := the lowest value allowed to be input

hilimit := the highest value allowed to be input

The MENU INPUT statement allows the background menu routine to update predefined menus with number or character string input.

When used for numeric input, the specified default value is initially displayed on the LCD at the current location. Numeric entry is accepted from the keypad. When the Enter key is pressed, the value entered is compared against the low and high limits and, if valid, that value is returned. Otherwise, the default value is returned.

For character string input, the default value must be specified as a string array "$(n)". When this is done, the first value displayed is the string in the $ string array defined by the default variable. When the up and down arrow keys are pressed, the next or previous string is displayed until the lolimit or hilimit is reached. Pressing the Enter key causes the current value to be returned.

In the example below, two pages are defined. Menu page 2 allows configuration modification of two items stored in a configuration array.

```
10      STRING 200,10: $(1)="Floats": $(2)="4/20mA"  REM Define strings
20      SYSTIME   :   POP SC,MN,HR,DY,DT,MO,YR              REM  Get the time
30      MENU (1,2)="  TCU TEST PROGRAM"                     REM  Set up
40      MENU (1,3)="     Time -",HR,":",MN                  REM  page1
50      MENU (2,2)="Xducer type = ",$(CFG(1))        REM  Set up
60      MENU (2,3)="   No. pumps = ",CFG(2)                REM  page 2
95      MENU ON
100     DO
110     DO: C=GET UNTIL C=13                                REM  Wait for Enter key
120     MENU: POP P,L                                       REM  get page and line
0       REM    If we are on page 2 line 2, input string
130     IF ((P=2) .AND. (L=2)) THEN MENU INPUT $(CFG(1)),1,2:  POP I:  CFG(1)=I
0       REM    If we are on page 2 line 3, input numeric
140     IF ((P=2) .AND. (L=3)) THEN MENU INPUT CFG (2),1,3:  POP I: CFG(2)=I
200     UNTIL 0
```

MENU PLOT

Format: MENU PLOT (page, top, bottom, left, right) = expr

Mode: Command; Run

Type: Output; DFS Special

Parameters:

page := the menu page that the plot is to be on

top := the top line to be used by the plot

bottom := the bottom line to be used by the plot

left := the left column to be used by the plot

right := the right column to be used by the plot

expr := value to plot (0.00 to 1.00)

This variation of the MENU statement allows trend graphs to be plotted on the LCD display. Graphs are displayed by sending special bar characters to the LCD. The maximum graph would have 20 columns each of which would have 28 possible levels.

The page variable defines the menu page on which the graph is to be placed. The top, bottom, left, and right variables define a box that the graph is to be placed in. Each time the MENU PLOT routine is executed for a specific page, the entire graph is shifted to the left, and the expression's (expr) new value is graphed into the right column.

In the example below, a bar graph is made on menu page 1 using the entire LCD display area with the height of each bar equal to its column number.

```
>10     MENU ON                 REM Turn MENUing on
>20     FOR I=0 TO 20                   REM For each column on display
>30     MENU PLOT(1,1,4,1,20)=I/20      REM graph a column whose height = its column number
>40     NEXT I
```

ON Statement

Format: ON [expr] GOSUB [ln num], [ln num],...[ln num]

ON [expr] GOTO [ln num], [ln num],...[ln num]

Mode: Run

Type: Control

The ON statement provides "conditional branching" options within the constructs of a DFS BASIC-52 program. All properties of the GOTO and GOSUB statements are the same when used with the ON statement as when they are used independently of the ON statement.

The value of the expression following ON is the number in the GOSUB/GOTO line number list to which control will be transferred. The expression’s value must always be an integer equal to or greater than zero, but less than the number of items in the line number list. The first line number in the GOSUB/GOTO list is always designated when the expression is equal to zero.

Notice that the number of line numbers listed (four in both examples) is equal to the number of values the X value can hold (0-3 is four digits).

- If X is equal to zero, control is transferred to line number 100. If X is equal to one, control is transferred to line number 200, etc.
- If X is less than zero, a BAD ARGUMENT error will be generated.
- If X is greater than the GOSUB/GOTO line number list, a BAD SYNTAX error will be generated.

The number of line numbers in the list is only restricted by the number of line numbers that can be entered after GOSUB/GOTO before the 79-character limit of a line of code is reached.

See the next page for examples of using the ON statement with GOSUB and GOTO.

ON with GOSUB

```
>LIST
10     FOR X=0 TO 3
20     ON X GOSUB 100,200,300,400
30     NEXT X
40     END
100    PRINT "100 ",
110    RETURN
200    PRINT "200 ",
210    RETURN
300    PRINT "300 ",
310    RETURN
400    PRINT "400 ",
410    RETURN

READY
>RUN

100 200 300 400
READY
>
```

ON with GOTO

```
>LIST
10     INPUT "ENTER A NUMBER (0-3)",X
20     IF (INT(X)<0).OR.(INT(X)>3) GOTO 10
30     ON X GOTO 100,200,300,400
100     PRINT "YOU ENTERED A '0'"
102     END
200     PRINT "YOU ENTERED A '1'"
202     END
300     PRINT "YOU ENTERED A '2'"
302     END
400     PRINT "YOU ENTERED A '3'"
402     END

READY
>RUN

ENTER A NUMBER (0-3)5
ENTER A NUMBER (0-3)2
YOU ENTERED A '2'

READY
>
```

ONERR Statement

Format: ONERR [ln num]

Mode: Run

Type: Control

With the ONERR statement, the programmer can handle any arithmetic errors that may occur during program execution. The only errors that can be “trapped” by ONERR are:

- ARITH. OVERFLOW
- ARITH. UNDERFLOW
- DIVIDE BY ZERO
- BAD ARGUMENT

If an arithmetic error occurs after the ONERR statement is executed, the DFS BASIC-52 interpreter will pass control to the line number following the ONERR statement. The programmer can handle the error condition in any manner suitable to the particular application. Typically, ONERR should be viewed as an easy way to handle errors that occur when the user provides inappropriate data to an INPUT statement.

With ONERR, the programmer has the option of determining what type of error occurred. This is done by examining external memory location 257 (101H) after the error condition is trapped. The error codes are as follows:

10=DIVIDE BY ZERO

20=ARITH. OVERFLOW

30=ARITH. UNDERFLOW

40=BAD ARGUMENT

This location may be examined by using an XBY(257) statement.

PH0., PH1., PH0.#, PH1.# Statements

Format: PH0.; PH1.; PH0.#; PH1.#

Mode: Command; Run

Type: Input/Output

The PH0. and PH1. statements have the same functionality as the PRINT statement except that the values are printed out in a hexadecimal format.

- The PH0. statement suppresses two leading zeros if the number to be printed is less than 255 (0FFH).
- The PH1. statement always prints out four hexadecimal digits.

When PH0. or PH1. is used to direct an output, the character "H" is always printed after the number and the values printed are always truncated integers. If the number to be printed is not within the range of valid integers [that is, between 0 and 65535 (0FFFFH), inclusive], DFS BASIC-52 defaults to the normal mode of print. When this happens, no "H" is printed out after the value.

Since integers can be entered in either decimal or hexadecimal form, the statements PRINT, PH0., and PH1. can be used to perform decimal to hexadecimal conversion. All comments that apply to the PRINT statement apply to the PH0. and PH1. statements. PH0.# and PH1.# do the same thing as PH0. and PH1. respectively, except that the output is directed to the list device instead of the console device.

Examples

```
>PH0.  2*2
04H    0004H

>PH1.  2*2
153

>PRINT  99H
64H

>PH0.  100

>PH0.  1000
3E8H   03E8H

>PH1.  1000
1000

>P.  3E8H
03H

>PH0.  3.1415926
```

POP Statement

Format: POP [var]

Mode: Command; Run

Type: Assignment

With the POP statement, the top of the argument stack is assigned to the variable following POP and the argument stack is "POPped" (that is, incremented by 6). Values can be placed on the stack by:

- The PUSH statement
- Telemetry input statements DGIN, ANIN or SYSTIME
- A DFS Special command like CHKTIMER.

If a POP statement is executed and no number is on the argument stack, an A-STACK error is returned.

Variation

More than one variable can be “POPped” off the argument stack with a single POP statement. The variables are simply followed by a comma (that is, POP [var],[var],.....[var]).

POP statement with single variable

```
>LIST
5     REM SETTING AND WATCHING A TIMER
10     PUSH 10 :  SETIMER 1
20     CHKTIMER 1 :  POP TD1
30     IF (TD1<>X) THEN  PRINT TD1,
40    X=TD1
50     IF (TD1<>0) THEN  GOTO 20

READY
>RUN

 10  9  8  7  6  5  4  3  2  1  0
READY
>
```

POP Statement with multiple variables

```
>LIST
5     REM VIEW SYSTEM STATUS
10     SYSCHECK  :  POP EFLT,RFLT,MFLT
20     PRINT EFLT,RFLT,MFLT

READY
>RUN

 0  1  65535

READY
>
```

The PUSH and POP statements can be used to avoid the global variable problems so often encountered in BASIC programs. This problem arises because in BASIC, the "main" program and all subroutines used by the main program are required to be the same variable names (that is, global variables). It is not always convenient to use the same variables in a subroutine as in the main program, and you often see programs re-assign a number of variables (for example, A=Q) before a GOSUB statement is executed. If some variable names are reserved ***just*** for subroutines (for example, S1,S2), values can be passed to these variables by using the stack instead of the LET statement. This also helps avoid errors caused by improperly assigning values to global variables within the subroutines. See the example on the next page.

Using POP and PUSH with global variables

```
>LIST
10     FOR X=1 TO 5
20     PUSH X
30     GOSUB 100
40     POP B,A
50     PRINT A,B
60     NEXT X
70     END
100    POP S1
110   S2=SQR(S1)
120    PUSH S1,S2
130    RETURN

READY
>RUN

 1  1
 2  1.4142136
 3  1.7320508
 4  2
 5  2.236068

READY
>
```

PRINT or P. or ? Statement

Format: PRINT; P.; ?

Mode: Command; Run

Type: Input/Output

The PRINT statement directs DFS BASIC-52 to output to the console device. The value of expressions, strings, literal values, variables, or test strings can be printed. The various forms can be combined in the print list by separating them with commas. If the list is terminated with a comma, the carriage return/line feed will be suppressed. Note that P. and ? are “shorthand” notations for PRINT.

When PRINT is executed, values are printed on the same line with two spaces between them. A PRINT statement with no arguments causes a carriage return/line feed sequence to be sent to the console device.

```
>PRINT 10*10,3*3
100  9

>PRINT "DFS-51"
DFS-51

>PRINT 5,1E3
5  1000
```

Special Print Formatting Statements

CLEAR SCREEN & RETURN HOME

Two print statements that are very useful in formatting VT100 display screens use the CHR( ) string operator explained in Chapter 3: Operators and Expressions. Many times, it is helpful to be able to clear the display screen, or send the cursor to the “home” position in the upper left corner of the display screen.

To clear the screen, use this statement in Command or Run mode:

```
PRINT CHR(27),”[2J”,
```

To position the cursor “home,” use this statement in Command or Run mode:

```
PRINT CHR(27),”[H”,
```

CR

The CR function is interesting and unique to DFS BASIC-52. When CR is used in a PRINT statement (followed by a comma), it will force a carriage return, but no line feed. This can be used to create one line on a CRT device that is repeatedly updated.

Print formatted with CR (followed by a comma)

```
>LIST
10     FOR X=1 TO 5
20     PRINT X, CR ,
30     NEXT X

READY
>RUN

 5
READY
>
```

Print statement formatted with CR (no comma)

```
>LIST
10     FOR X=1 TO 5
20     PRINT X, CR
30     NEXT X

READY
>RUN
 1
 2
 3
 4
 5

 READY
>
```

SPC([expr])

The SPC function is used in the PRINT statement to cause DFS BASIC-52 to output the number of spaces in the SPC argument [expr]. The following example shows how SPC can be used to place an additional 5 spaces between the A and B over and above the two that would normally be printed.

```
PRINT A,SPC(5),B
A       B
```

TAB([expr])

Using TAB in the PRINT statement enables you to specify the exact location where data is to be printed on the output device. TAB([expr]) tells DFS BASIC-52 which position to begin printing the next value in the print list. If the print head or cursor is on or beyond the specified TAB position, DFS BASIC-52 ignores the TAB function.

PRINT statement formatted with TAB

```
PRINT TAB(5),"X",TAB(10),"Y"
     X          Y

PRINT TAB(20),”A”,CR,TAB(5),”B”
     B                    A
```

USING(special characters)

USING tells DFS BASIC-52 in what format to display the printed values. Because DFS BASIC-52 "stores" the desired format after the USING function is executed, all outputs following a USING statement will be in the format evoked by the last executed USING function. Therefore, the USING Function does not need to be executed within every PRINT statement unless the programmer wants to change the format. Note that U. is a "shorthand" notation for USING. The options for USING are as follows:

PRINT USING(Fx) – This forces DFS BASIC-52 to output all numbers using the floating-point format. The value of x determines how many significant digits will be printed. The maximum value for x is eight. If x equals zero, DFS BASIC-52 will not output any trailing zeros. In this case, the number of digits will vary depending on the number being printed. DFS BASIC-52 will always output at least three significant digits even if x is one or two. This format always "aligns" the decimal points when printing series of numbers, which makes displayed columns of numbers easy to read.

PRINT statement formatted with USING (Fx)

```
>LIST
10     PRINT USING(F3),1,2,3
20     PRINT USING(F4),1,2,3
30     PRINT USING(F5),1,2,3
40     FOR X=10 TO 40 STEP 10
50     PRINT X
60     NEXT X

READY
>RUN

1.00 E 0  2.00 E 0  3.00 E 0
1.000 E 0  2.000 E 0  3.000 E 0
1.0000 E 0  2.0000 E 0  3.0000 E 0
1.0000 E+1
2.0000 E+1
3.0000 E+1
4.0000 E+1
```

PRINT USING(#.#) - This forces DFS BASIC-52 to output all numbers using an integer and/or fraction format. The number of "#" 's after the decimal point represents the number of significant integer digits that will be printed in the fraction. The maximum number of "#" characters is eight. The decimal point can be omitted, in which case only integers will be printed. USING(###.###), USING(######) and USING(######.##) are all valid in DFS BASIC-52. If DFS BASIC-52 cannot output the value in the desired format (usually because the value is too large), a question mark (?) is printed to the console device. When this occurs, BASIC outputs the number in the free format [USING(0)] described below. When a series of numbers fit the designated format, the numbers always "align" at the decimal points, which makes displayed columns of numbers easy to read.

PRINT statement formatted with USING (#.#)

```
>LIST
10     PRINT USING(##.##),1,2,3
20     FOR X=1 TO 200 STEP 50
30     PRINT X
40     NEXT X

READY
>RUN

1.00   2.00   3.00
1.00
51.00
? 101
? 151
```

PRINT USING(0) - This format allows DFS BASIC-52 to determine what format to use.

- If the number is between 0.1 and 99999999, or -0.1 and -99999999, the display is in integers and fractions.
- If it is out of this range, the display defaults to the USING(F0) format.

Leading and trailing zeros are always suppressed. After reset, DFS BASIC-52 is placed in the USING(0) format.

PRINT@ or P.@ or ?@ Statement

Format: PRINT@; P.@; ?@

Mode: Command; Run

Type: INPUT/OUTPUT

The PRINT@ (shorthand notation: P.@ and ?@) statement performs the same function as the PRINT statement except that the output is directed to the TCU's LCD (when the MENU function is turned OFF) instead of the console device. Remember that the LCD is limited to four lines of 20 characters each. Any print information exceeding 20 characters will truncate on the LCD, so that only the first 20 characters are displayed.

PRINT# or P.# or ?# Statement

Format: PRINT#; P.#; ?#

Mode: Command; Run

Type: Input/Output

The PRINT# (shorthand notation: P.# and ?#) statement performs the same function as the PRINT statement except that the output is directed to the list device instead of the console device. Before the PRINT# statement is used, the BAUD rate to the list device must be initialized by the statement BAUD[expr]. All comments that apply to the PRINT statement apply to the PRINT# statement.

PUSH Statement

Format: PUSH [expr]

Mode: Command; Run

Type: Assignment

This statement provides a simple means of passing parameters to the telemetry output statements DGOUT and ANOUT. Additionally, the PUSH (and POP) statements can be used to "swap" variables and pass parameters to and from DFS Special routines such as the SETIMER and SYSTIME SET. The arithmetic expression, or expressions, following the PUSH statement are evaluated and then sequentially placed on the argument stack. The last value "PUSHed" (see PUSH statement, page 45) onto the argument stack will be the first value "POPped" (see the POP statement, page 39) off the argument stack.

Variations:

A single PUSH statement can be used to push multiple expressions onto the argument stack by separating each expression with a comma (PUSH [expr],[expr],.....[expr]). The last value pushed onto the argument stack will be the last expression [expr] encountered in the PUSH statement.

PUSH used to swap variables

```
>LIST
5     REM SWAPPING VARIABLES
10    A=10
20    B=20
30     PRINT A,B
40     PUSH A,B
50     POP A,B
60     PRINT A,B

READY
>RUN

 10  20
 20  10

READY
>
```

PUSH used to set system time

```
>LIST
5      REM SETTING THE SYSTEM TIME
10    HR=5 : MN=20 : SC=13
20    YR=1997 : MO=5 : DT=12
30    DY=2
40     PUSH SC,MN,HR,DY,DT,MO,YR
50     SYSTIME SET
60     SYSTIME
70     POP A,B,C,D,E,F,G
80     PRINT A,B,C,D,E,F,G

READY
>RUN

 13  20  5  2  12  5  1997

READY
>
```

REM Statement

Format: REM

Mode: Command; Run

Type: Control – performs no operation

REM, short for remark, allows you to add comments to a program. Although comments have no affect on a program's functionality, they are useful in that they help make a program a little easier to understand. When a REM statement appears at the beginning of a line, the entire line is assumed to be a remark. You can terminate a REM statement with a colon (:) to allow another statement to follow it. However, you can place a REM ***after*** a colon, which allows you to place a comment on each line. Exercise caution when inserting remarks as these comments use memory that may be needed for actual program code.

When developing a program with a full screen text editor, an unlimited number of REMarks can be used by numbering the line '0'. Any line beginning with a '0' is ignored by Bload when downloading the file to the TCU. In this manner, you can generate a soft and hard copy of the program with thorough documentation while maximizing use of the TCU's memory for the coded program and essential comments.

REMarks inserted on separate lines

```
>LIST
10     REM INPUT 2 VARIABLES
20     INPUT A,B
30     REM MULTIPLY THE 2 VARIABLES
40    Y=A*B
50     REM PRINT THE EQUATION AND THE ANSWER
60     PRINT A,"*",B,"=",Y

READY
>RUN

?4,6
 4 * 6 = 24

READY
```

REMarks inserted after a colon

```
>LIST
10     INPUT A,B : REM INPUT 2 VARIABLES
20     Y=A*B : REM MULTIPLY THE 2 VARIABLES
30     REM PRINT THE EQUATION AND THE ANSWER
40     PRINT A,"*",B,"=",Y

READY
>RUN

?4,6
 4 * 6 = 24

READY
>
```

The following will ***not*** work because the entire line would be interpreted as a REMark, so the PRINT statement would not be executed:

```
>LIST
10     REM PRINT THE NUMBER : PRINT A
```

Programmer's Note:	There is a special function carried out with the REM statement. When typing directly in the TCU's RAM, the following command (in all capital letters) can be entered to prevent the contents of the RAM from being erased when power is cycled to the TCU: 0 REM DEBUG.

RROM Statement

Format: RROM {integer}

Mode: Command; Run

Type: Control

RROM, which stands for RUN ROM, is used to select and execute a program in the EPROM file {1-8}. The integer after the RROM statement selects which program in the EPROM file is to be executed. If no integer is entered, the program in ROM location 1 is executed by default.

In Command mode, RROM 2 would be equivalent to typing ROM 2 then RUN. However, RROM {integer} is a statement, which means that a program that is already executing can actually force the execution of a completely different program located in the EPROM file. This gives you the ability to "change programs" on the fly.

If a RROM statement is executed in a running program, and an invalid integer is entered (say 6 programs are contained in the EPROM file and the program executes RROM 8), no error is generated. DFS BASIC-52 simply executes the statement following the RROM statement.

Every time the RROM statement is executed, all variables and strings are set equal to zero. As a result, variables and strings ***cannot*** be passed from one program to another by using the RROM statement. Note, however, that modules defined with the DEFMOD statement are ***not*** cleared from memory location blocks 6000H to 7000H. Refer to the XBY statement – Module I/O Memory manipulation section (pages 9-5 and 9-6) of the PLC001/SCU001 Operations Guide for more information (DFS personnel only).

SETIMER Statement

Format: SETIMER [integer]

Mode: Command; Run

Type: Input/Output – DFS Special

This command sets a countdown timer for a specific numbers of seconds. The value in seconds must be an integer "PUSHed" (see PUSH statement, page 45) onto the argument stack immediately before using the SETIMER statement. The number of seconds can be 1 to 65535 and can be represented with a variable or arithmetic expression. There can be 128 different countdown timers (0-127). This command is always used in conjunction with the CHKTIMER command.

Both the SETIMER and CHKTIMER commands utilize the argument stack. An integer value up to 65535 is "PUSHed" onto the argument stack. The SETIMER command retrieves this value from the argument stack and stores it into the timer designated after the SETIMER command.

In the following example, if pump #1 is not called (PC(1) = FA), timer 1 is set for 2 minutes (120 seconds). Once pump #1 is called, timer 1 is no longer reset and begins timing out. The CHKTIMER command is used to retrieve the current value of the counting timer and place the value on the argument stack. This value is assigned to the TD(1) variable using the POP command. Once the timer has expired [TD(1)=0], if pump #1 is not running [PS(1) = FA], the pump #1 starter fault alarm [PF(1)] is set true. Once the pump is not called and the timer is reset, or pump #1 is running, the starter fault alarm clears. This same test is performed for pump #2 and pump #3 with the use of the FOR -- NEXT loop and the utilization of arrays. Typically, the pump calls would be sent out through telemetry using DGOUT statements; the pump statuses would be monitor points retrieved through telemetry using DGIN statements; and the fault statuses would be output using DGOUT statements.

```
>LIST
10     DIM PC(NPMP+1), PS(NPMP+1), PF(NPMP+1), TD(NPMP+1)
20     REM PC=PUMP CALL, PS=PUMP STATUS, PF=PUMP FAULT, TD=TIME DELAY
100    FOR X=1 TO 3
110    IF NOT(PC(X)) THEN  PUSH 120 :  SETIMER X
120    CHKTIMER X :  POP TD(X)
130   PF(X)=(TD(X)=0).AND.NOT(PS(X))
140    NEXT X
```

ST@ Statement

Format: ST@ [expr]

Mode: Command; Run

Type: Input/Output – DFS Special

DFS BASIC-52 reserves 1008 bytes of non-volatile memory (starting at location 5000H) for the purpose of storing and retrieving floating point set point variables in battery backed-up (non-volatile) memory. This is useful in programming when the RTU is powered down for any reason, because it allows previously assigned set points to recover their last set value. Up to 168 basic variables (six bytes per variable) can be stored in non-volatile memory using the ST@ command and retrieved using the LD@ command.

ST@ lets you specify where in non-volatile memory DFS BASIC-52 floating point numbers are to be stored. The expression [expr] following ST@ specifies the address where the number is to be stored. The number to be stored must be "PUSHed" (see PUSH statement, page 45) onto the argument stack prior to the ST@ command being executed.

See LD@ command for additional information on page 28.

STOP Statement

Format: STOP

Mode: Run

Type: Control

The STOP statement allows you to break program execution at specific points in a program. After a program is STOPped, variables can be displayed and/or modified. Program execution can be resumed with the CONTinue command. The purpose of the STOP statement is to allow for easy program "debugging."

Notice in the example on the next page that the line number printed out after the STOP statement is executed in the line number following the STOP statement, ***not*** the line number that contains the STOP statement.

```
>LIST
10     FOR X=1 TO 100
20     PRINT X,
30     IF (X=4) STOP
40     IF (X=30) END
50     NEXT X

READY
>RUN

 1  2  3  4 STOP - IN LINE  40
READY
>X=25

>CONT

 26  27  28  29  30
READY
>
```

STRING Statement

Format: STRING [expr],[expr] statement

Mode: Command; Run

Type: Assignment

The STRING statement is used to allocate memory for strings.

- The first expression in the STRING statement is the total number of bytes you want to allocate for string storage.
- The second expression denotes the maximum number of bytes (or characters) that are in each string.

These two numbers determine the total number of defined string variables.

Initially, no memory is allocated for strings. If you attempt to define a string with a statement such as LET $(1) ="HELLO" before memory has been allocated for strings, a MEMORY ALLOCATION error

is returned. Note that the total number of defined strings is not equal to the first expression in the STRING statement divided by the second expression. DFS BASIC-52 requires one additional byte for each string, plus one additional byte overall. This means that the statement STRING 100,10 would allocate enough memory for nine string variables (maximum length of 10 bytes or characters), ranging from $(0) to $(8) and all of the 100 allocated bytes would be used. Note that $(0) is a valid string in DFS BASIC-52.

Memory allocated for string storage is not de-allocated unless:

- A STRING 0,0 statement is executed
- The TCU is reset with a CALL 0 statement
- Power is cycled.

Commands such as NEW or statements such as CLEAR, will not de-allocate this memory.

String Expression Calculation

The equation below is used to calculate the first expression [expr] in the string statement. The first expression (expr 1) is the total number of memory bytes allocated for strings. The second expression (expr 2) is the maximum number of bytes (or characters) desired to be in each string variable.

expr 1 = (# of string variables) x (expr 2 + 1) + 1

In the example below, we know that we want 20 string variables [$(0) to $(19)] each with a maximum length of eight characters.

expr 2 = 8

expr 1 = [20 x (8 + 1)] + 1 = 181

The final STRING statement would then be:

STRING 181,8

See Chapter 3: Operators and Expressions for information on using string variables.

IMPORTANT: Every time the STRING statement is executed, DFS BASIC-52 executes the equivalent of a CLEAR statement. This is necessary because string variables and numeric variables occupy the same external memory space. Therefore, after the STRING statement is executed, all variables are "wiped out." Because of this, string memory allocation should be performed early in a program (the first statement or so), and string memory should never be "re-allocated" unless the programmer is willing to destroy all defined variables.

TAC II INTERFACE STATEMENTS

ANIN Statement

Format: ANIN [{r}Mx] statement

Mode: Command; Run

Type: Input - Telemetry

This command retrieves the analog status from an analog module or a Pump Control Unit as well as pulse counts from a digital monitor or digital control module. Data can be retrieved from a local module M point x, or a remote station r module M point x, and is placed onto the argument stack. The command line parameters are:

r := the remote station address if required (1 - 15); (not used when addressing local modules)

M := the module address (A - O)

x : = the point number (see list below)

- (1-4) all AMMs
- (5-12) DCM003
- (1-12) DMM002
- (1-4,9) PCU001

The value must be taken off the argument stack with the POP statement immediately after executing the ANIN statement (see lines 110 and 120 in the example below).

- An analog input value of 0-20mA or 0-5V is linearly scaled.
- An input value of 4-20mA will be linearly scaled 819-4095 system units (su).
- For Pulse points, the value retrieved will be the number of pulses counted since the previous interrogation during the POLLON cycle. [NOTE: Pulse input points may not be monitored by the TCU Basic program ***and*** the central telemetry polling device (Hyper SCADA Server, central computer, PLC, TCU, or SCU) on versions before 5.5. If pulse points need to be recorded at the central, do not perform the ANIN command on the configured pulse point.]

In the following example, a pressure transducer is being monitored at module A point 1, and a transducer with a pulsed output (such as a tipping bucket rain gauge) is being monitored at module B point 12. In line 200, the pressure value retrieved in system units (0-4095) is converted into engineering units (psi) based on a transducer range of 0-30 psi with a scale of 4-20 mA. When the transducer is measuring 0 psi, it delivers a 4mA signal to the AMM that converts the 4 mA to 819 su, and line 200 calculates the pressure as being 0 psi. The retrieved values are then printed to the screen. If the pressure (PRES) is greater than 20 psi, a high-pressure indication is also printed to the screen.

```
>LIST
10     DEFMOD A,AMM002 : REM LOCAL MODULE A=ANALOG MONITOR
12     DEFMOD B,DCM002,1 : REM LOCAL MODULE B=DIGITAL CONTROL WITH 1 PULSE POINT AT B12
20     POLLON:POLLOFF
100     POLLOFF
110     ANIN A1: POP PRES
```

(continued on next page…)

```
120     ANIN B12: POP CNTS
150     POLLON
200     PRES = (PRES-819)/3276* 30
210     TTL=TTL+CNTS
300     PRINT "   PRESSURE = ",PRES,"psi",
310     IF (PRES>20) THEN PRINT "PRESSURE HI", ELSE PRINT "PRESSURE OK",
320     PRINT “   TOTAL PULSES = “,TTL,
330     PRINT CR,
400     GOTO 100

READY
>
```

ANOUNT Statement

Format: ANOUT [{r}Mx]

Mode: Command; Run

Type: Output - Telemetry

This command outputs the value on the top of the argument stack to one of the following:

- The local analog or digital output module M point x.
- The remote analog or digital output station r module M point x.
- The onboard LED y.

The command line parameters are:

r := the remote station address if required (1 - 15); (not used when addressing local modules)

M := the module address (A - O)

x := the point number (see list below)

- (1-4) ACM001, DCM002, DCM003-2, DCM003-4, DCM003-6, DUMACM
- (1-8) DCM001, DCM003-1, DCM003-3, DCM003-5
- (9,25-39) PCU001

y := the LED display number (see list below)

- (1-13) TCU001
- (7-10) PLC001
- (1-10, 15) SCU001

The control value must be placed onto the argument stack with the PUSH statement immediately preceding the ANOUT statement (see line 120 in the example below).

If an analog point is being controlled, the pushed value must be in system units (su) 0-4095, which is linearly scaled 0-20 mA in the ACM. The transducer wired to the ACM or the TACII configuration of the point must also be scaled based on the 0-4095su / 0-20mA scales.

If a digital control point is being used as a momentary output, the pushed value must be in seconds (1-63). The value in seconds is the duration the digital point will remain in the On state before turning Off.

If the point receives another value with the ANOUT statement before the timer expires, the timer will reset to the new value. This statement provides an easy method to control a watchdog circuit monitoring the operation of the TCU foreground program or other operations controlled by the TCU.

Programmer's Note:	If the ANOUT statement is used to pulse a digital control point for 1-63 seconds, a DGOUT statement has no control of the digital control point while the duration timer for that point (>0) in the DCM is actively running. A value of '0' must be output to the digital point with the ANOUT statement to override the actively running timer. Once the timer is '0' after timing out or forced to '0' with the ANOUT statement, the DGOUT statement will then work as normal on the digital control point.

In the example below, module B point 1 is being used as a watchdog point. If the point turns off, this indicates that one of the following events has occurred:

- Power to the control module has failed.
- The foreground program in the TCU has stopped.
- The polling operation of the TCU has somehow failed.

Module C point 1 is used to control the speed of a VFD from 0-100% based on pressure with a 4-20 mA signal. In the TCU, the speed (0-100%) must be calculated in system units (819-4095 scale) for the ACM to convert to the respective 4-20 mA signal.

```
>LIST
10     DEFMOD A,AMM002 : REM MODULE A=ANALOG MONITOR
12     DEFMOD B,DCM002 : REM MODULE B=DIGITAL CONTROL WITH 4 CONTROL POINTS
14     DEFMOD C,ACM001 : REM MODULE C=ANALOG CONTROL
20     POLLON : POLLOFF : POLLON : REM INITIAL POLLON
100     POLLOFF
110     ANIN A1:POP PRES
120     PUSH 60:ANOUT B1 : REM WATCHDOG
130     PUSH (SPD/100*3276+819):ANOUT C1 : REM 3276 = 4095 - 819;  16 mA = 20 - 4;  =  RANGE
200     POLLON
300     SPD=SPD+(PRES-PRESL)*0.015 : REM SPEED CONTROL BASED ON PRESSURE INPUT
310     IF (SPD>100) THEN SPD=100
320     IF (SPD<0) THEN SPD=0
330     PRESL=PRES
500     GOTO 100
```

DEFMOD Statement

Format: DEFMOD [{r}M, type]

Mode: Command; Run

Type: Assignment - Telemetry

This command defines the DFS modules that are to be polled by the TCU. The command line parameters are:

r := the remote station address if required (1 - 15); (not used when addressing local modules)

M := the module address (A - O)

type := one of the following module types

> When programming a TCU, only dummy modules and remote station modules can be defined using the DEFMOD statement. No local modules can be added to the fixed, internally defined modules of a TCU.

The TCU's fixed, internally defined modules are:

- Module A: DMM002
- Module B: DCM001
- Module C: AMM002
- Module R: RIM006

The DEFMOD statement is not needed to define these modules since they are hard coded into the TCU. The internal AMM002 of the TCU contains no hardwire qualifier points like an Analog Monitor Module, so the analog values are considered to always be qualified. For more information on the internally fixed modules, refer to the TCU I/O Map in Chapter 1: Product Overview of the *TCU Installation and Operation Manual*.

Type	Defines Real Modules (# - see notes on next page)
ACM001,(0-8) [1]	ACM001
AMM001	AMM001; AMM002
AMM002	AMM001; AMM002
DCM001	DCM001; DCM011; DCM003-1; DCM003-3; DCM003-5
DCM002	DCM002
DCM003-1,(0-4) [2]	DCM003-1; DCM003-3; DCM003-5
DCM003-2,(0-8) [2]	DCM003-2; DCM003-4; DCM003-6
DMM001	DMM001; PCM001
DMM002,(0-12) [2]	DMM002
DUMACM	(none) [3]
DUMDCM	(none) [3]

1. The Analog Control Module (ACM001) has an added feature that allows the analog output slew rate to be set at the module type definition. This value defaults to zero when no comma or number is entered after the card type. The slew rate adjustment effects all four control points for that card, but the card can be redefined (slew rate changed) anywhere in the program (for example, DEFMOD C, ACM001,3).
2. Digital Control Modules (DCM003) and Digital Monitor Modules (DMM002) have an added feature which allows one or more of the monitor points to count pulses (the number of times the point is turned on and off) instead of just monitoring the off/on state. The number indicated after the module type instructs the hardware module how many points are to be used as Pulse Accumulator points.
   - If a number is not entered after the module type, the number of pulse points is zero.
   - If a ‘,1’ is entered after the module type, point 12 on the module works as a pulse point.
   - If a ‘,3’ is entered after the module type, points 12, 11, and 10, respectively, will work as pulse points.
   - If the TCU is being used with HyperTAC II (not as a central site), the HyperTAC II module configuration will override any pulse point definition used in the DEFMOD statement. (See ANIN for information on retrieving pulse data.)
3. The Dummy Analog Control Module (DUMACM) and Dummy Digital Control Module (DUMDCM) are used when assigning virtual I/O modules within the TCU. These modules are not polled on the module bus, but are polled like real modules from the central HyperTAC II configuration. They are used to communicate derived status and control points between the central site and PLC. A DUMACM may be configured as any analog module in HyperTAC II, and a DUMDCM may be configured as any digital module in HyperTAC II. Keep in mind that each TCU has three real hardware modules that are automatically configured as A, B, and C. The remainder of the modules (D-O) can be either DUMDCM or DUMACM depending on the BASIC process routine.

When defining a remote module in a TCU operating as a central, the RIM for that station is automatically configured internally as module R. The remote radio may be polled for generic digital and analog statuses (analog status is only valid with the RIM006 or later).

Digital status points

R1 := Power supply shut-down, for battery test

R11 := DC Bias status

R12 := AC Power status

Analog status points

R1 := Average current draw when the radio is keyed

R2 := Average radio signal strength (RSSI)

R4 := Average current draw when the radio is not keyed

In the following example, the TCU is acting as the central site RTU.

- Module A is defined as a local digital monitor module.

- Module B defined as a local digital control module with 4 control points and point 12 operating as a Pulse Accumulator point
- Module C defined as a local analog control module with a slew rate of zero
- Module 3A (station 3, module A) defined as an analog monitor module.

Notice that there are no dummy modules defined since there is no central to relay derived status or controls.

```
>LIST
10     DEFMOD A, DMM001 : REM LOCAL MODULE A=DIGITAL MONITOR
20     DEFMOD B, DCM002,1 : REM LOCAL MODULE B=DIGITAL CONTROL WITH 1 PULSE POINT AT B12
30     DEFMOD C, ACM001 : REM LOCAL MODULE C=ANALOG MONITOR
40     DEFMOD 3A, AMM002 : REM REMOTE STATION 3 MODULE A= ANALOG CONTROL

READY
>
```

Programmer's Note:	The remote station address definition is only used when the TCU is directly controlling other RTUs as if it were the central site (TCU/RTU address=0). Remote station addresses are not allowed when the TCU is in the standard HyperTAC II system (TCU/RTU address<>0). When addressing remote sites, the TCU is limited to polling stations addressed 1 through 15 only, and can only poll up to a total of fifteen modules between all fifteen sites.

DGIN Statement

Format: DGIN [{r}Mx]; DGIN SB[y]{,^}; DGIN SL[y]; DGIN SR[y]

Mode: Command; Run

Type: Input - Telemetry

This command gets the digital input status from one of the following:

- A local or internal module M point x
- A remote station r module M point x
- The left position status of the TCU switch SL[y]
- The right position status of the TCU switch SR[y]
- The status of the TCU's keys SB[y] (only when the TCU is in SCU compatibility mode)

It then places the status onto the argument stack.

The command line parameters are:

r := remote station address if required (1 - 15); (not used when addressing local modules)

M := module address (A - O, R); (R is only used when monitoring power of remote RTUs)

x := point number (1-4) AMM qualifier, (1-12) all digital, or (1-39) PCU

y := TCU's keys (1-3) where 1 = Up Arrow, 2 = Down Arrow, 3 = Enter (DGIN is only used to get status of key when the TCU is in SCU compatibility mode. In TCU mode, you must use the GET command.) ***or*** TCU's switches (1-3) where 1 = left switch, 2 = center switch, 3 = right switch.

,^ := see Positive Edge Trigger Option below

The value must be taken off the argument stack with the POP statement immediately after executing the DGIN statement (see lines 110, 120, and 140 in the example below).

- If a digital point is on, the retrieved value will be 65535.
- If a digital point is off, the retrieved value will be 0 (zero).

When programming a TCU for SCU compatibility mode, DGIN SB1 returns a value of 65535 if the up arrow key is pressed. If the key is not pressed, a value of zero is returned. If the left switch is in the left position, DGIN SL1 returns a value of 65535 and DGIN SR1 returns a value of zero. When the switch is in the center position, the status of both the SL1 and SR1 inputs is zero. If the switch is in the right position the SL1 status is zero, and the SR1 status is 65535.
When monitoring remote RTUs, the remote RIM's digital and analog points (analog points only valid for RIM006 or later) may be polled for status from the TCU central (for example, DGIN 2R12 : POP ACPWR2) in addition to the maximum 15 remote I/O function modules allowed.

Digital status points

R11 := DC Bias status

R12 := AC Power status

Analog status points

R1 := Average current draw when the radio is keyed

R2 := Average radio signal strength (RSSI)

R4 := Average current draw when the radio is not keyed

This example shows the retrieval of:

- The digital status from local module A point 1.
- The analog qualifier status from module B point 1.
- The analog value from module B point 1.
- The digital status from remote station 2 module A point 12.

It assigns the values of each point to the variable names PUMP1, QFLW, FLOW, and PUMP2, respectively, and prints user-friendly status information based on the value of each variable.

```
>LIST
10     DEFMOD A, DMM001 : REM DEFINE LOCAL MODULE
12     DEFMOD B, AMM002 : REM DEFINE LOCAL MODULE
20     DEFMOD 2A, DMC001 : REM DEFINE REMOTE MODULE
100     POLLON : POLLOFF
110     DGIN A1 : POP PUMP1
```

(continued on next page…)

```
120     DGIN B1 : POP QFLW
130     ANIN B1 : POP FLOW
140     DGIN 2A12: POP PUMP2
150     IF (PUMP1) THEN PRINT "PUMP1 ON  ", ELSE PRINT "PUMP1 OFF ",
160     IF (PUMP2) THEN PRINT "PUMP2 ON  ", ELSE PRINT "PUMP2 OFF ",
170     IF (QFLW) THEN PRINT "FLOW ON = “,FLOW,CR, ELSE PRINT "FLOW OFF. “,CR,
200     GOTO 100
```

To monitor the three keys of a TCU used in SCU compatibility mode, use the DGIN statement followed by the POP statement for each key.

- The up arrow key is defined as SB1.
- The down arrow key is defined as SB2.
- The Enter key is defined as SB3.

```
920 DGIN SB1 : POP INC
922 DGIN SB2 : POP DEC
924 DGIN SB3 : POP ENT
```

Positive Edge Trigger Option (,^)

The DGIN statement has the capability of detecting a positive edge trigger (greater than 250msec) of a digital point after the point has been off for at least 2.5 seconds. This option (,^) can be useful for monitoring the TCU’s keys (SCU compatibility mode) to get just a single response from a key being pressed instead of monitoring if the key is continuously pressed. In the following example, the up arrow key was pressed and held for three loops then released. Notice that while the key was held down the status of the edge trigger status variable (INCS) only stayed true the loop time the key was detected, and switched off the following loop even though the key was still pressed (INCC).

```
>LIST
100 DGIN SB1,^ : POP INCS :   REM DETECT KEYPRESS ONLY
102 DGIN SB1 : POP INCC :     REM DETECT STATUS OF KEY
104 PRINT INCS,INCC
106 GOTO 100

READY
>RUN
0  0
0  0
65535 65535
0  65535
0  65535
0  0
```

DGOUT Statement

Format: DGOUT [{r}Mx]; DGOUT DS[y]

Mode: Command; Run

Type: Output - Telemetry

This command outputs the value on the top of the argument stack to one of the following:

- The local digital output module M point x.
- The remote digital output station r module M point x.
- The onboard LED y.

The command line parameters are:

r := the remote station address if required (1 - 15); (not used when addressing local modules)

M := the module address (A - O)

x := the point number (see list below)

(1-4) DCM002, DCM003-2, DCM003-4, DCM003-6, DUMACM (AMM qualifier)

(1-8) DCM001, DCM003-1, DCM003-3, DCM003-5

(1-12) DUMDCM

(25-39) PCU

y := the LED display number (1-13)

The control value must be placed onto the argument stack with the PUSH statement immediately preceding the DGOUT statement (see lines 70 and 80 in the example on the next page).

- If a point is to be turned on, the value 65535 must be “PUSHed” onto the argument stack.
- If a point is to be turned off, the value 0 must be “PUSHed” onto the argument stack.

Using DGOUT to Control LEDs

The TCU’s programmable LEDs, which operate in a simple off/on manner, are controlled with the DGOUT statement. The programmable LEDs include:

- The LEDs below each of the three H-O-A switches
- The LEDs that are located on either side of the LCD
- The Alarm LED
- The LCD backlight

The LEDs that appear on either side of the LCD screen can be used in conjunction with information on the LCD to provide status at a glance. The TCU’s pump control process is designed this way. When you are viewing the default status screen, each of the LEDs corresponds to a condition (for example, HiWell) that is listed on the screen. A lit LED indicates that the station is currently in that state. You can create this type of status screen for a custom TCU application using the DGOUT and MENU statements.

The programmable LEDs (DS1-DS13) are controllable from within the BASIC program. In the TCU's BASIC program, the LEDs are designated as follows (e.g., PUSH 0 : DGOUT DS13):

DS1: LED below left switch	DS6: Top right LCD LED	DS11: Bottom left LCD LED
DS2: LED below middle switch	DS7: Second left LCD LED	DS12: Bottom right LCD LED
DS3: LED below right switch	DS8: Second right LCD LED	DS13: Alarm LED
DS4: LCD backlight*	DS9: Third left LCD LED	
DS5: Top left LCD LED	DS10: Third right LCD LED	

* You can control the LCD backlight with DGOUT when the menu is off. The menu function automatically controls the backlight when the menu is on.

DS4 is the backlight of the LCD display, and may be turned on and off when the MENU function is off. If the MENU function is on, the backlight will only light when any of the TCU's keys is depressed and will stay on for 20 seconds after the last key depress.

DS13 is an alarm indicator that illuminates anytime the foreground program stops. You must turn off this LED (PUSH 0 : DGOUT DS13) when the foreground program starts running, or the LED will remain lit. This LED may also be turned on (PUSH 65535 : DGOUT DS13) for any other alarm condition.

In this example, if there is a phase fault detected on Module A point 7, the pumps controlled at points A1 and A2 are turned off regardless of the value of the control variable (CTRL#) defined elsewhere in the program. In addition, LED 7 on the TCU is lit any time the phase fault is active.

```
>LIST
10     DEFMOD A,DCM001
20     TR=NOT(FA) :                          REM FA=0 AT PROGRAM START-UP WHICH MAKES TR=65535
50     POLLON:POLLOFF
60     DGIN A7 : POP PHAS :          REM IF PHAS IS OFF (0) THEN POWER IS LOST
70     IF (CTRL1).AND.(PHAS) THEN PUSH TR ELSE PUSH FA
72     DGOUT A1
80     IF (CTRL2).AND.(PHAS) THEN PUSH TR ELSE PUSH FA
82     DGOUT A2
90     PUSH NOT(PHAS) : DGOUT DS7
100     GOTO 50
```

Using DGOUT to Manipulate Qualifier Point Status

The DGOUT statement is also used when manipulating the qualifier point status of a dummy analog monitor module (defined in the TCU as a DUMACM, but configured as an AMM in HyperTAC II). In some cases, it may be necessary to calculate a flow rate or level in the TCU for reporting to the central computer. In order for the data sent back to the central to be qualified for reporting and alarms, you must turn the qualifier point on or off as required.

In this example, two flow rates are added together to produce a calculated total flow for report back to the central computer. The only time the value is qualified, however, is if one of the pumps producing

flow through the flow monitoring devices is running. (Note: To operate a digital control point as a pulsed output, refer to the ANOUT statement information above.)

```
>LIST
10     DEFMOD A,DCM002
12     DEFMOD B,AMM002
14     DEFMOD C,DUMACM :                    REM DEFINED AS AN AMM IN TACII
20     TR=NOT(FA) :                      REM FA=0 AT PROGRAM START-UP WHICH MAKES TR=65535
50     POLLON:POLLOFF
60     DGIN A5 : POP PS1 :                     REM GET PUMP 1 RUN STATUS
62     DGIN A6 : POP PS2 :                     REM GET PUMP 2 RUN STATUS
70     ANIN B1 : POP FLW1
72     ANIN B2 : POP FLW2
80     IF (PS1).OR.(PS2) THEN PUSH TR ELSE PUSH FA
82     DGOUT C1 :                     REM QUALIFY DUMMY ANALOG IF EITHER PUMP IS RUNNING
90     IF (PS1).AND.NOT(PS2) THEN PUSH FLW1
92     IF (PS2).AND.NOT(PS1) THEN PUSH FLW2
94     IF (PS1).AND.(PS2) THEN PUSH (FLW1+FLW2)
96     IF NOT(PS1.OR.PS2) THEN PUSH 819 :       REM 819 = 0 GPM
98     ANOUT C1 :             REM OUTPUT CALCULATED FLOW THROUGH DUMMY ANALOG POINT
100     GOTO 50

READY
>
```

Programmer's Note:	If the ANOUT statement is used to pulse a digital control point for 1-63 seconds, a DGOUT statement has no control of the digital control point while the duration timer is actively running for that point (>0) in the DCM. A value of ‘0’ must be output to the digital point with the ANOUT statement to override the actively running timer. Once the timer is ‘0’ after timing out or forced to ‘0’ with the ANOUT statement, the DGOUT statement will then work as normal on the digital control point.

POLLOFF Statement

Format: POLLOFF

Mode: Command; Run

Type: Control - Telemetry

This command disables the background local and/or remote module polling and control point updating enabled with the POLLON statement (see POLLON). This command should be implemented prior to a block of I/O transfers with remote modules using ANIN, ANOUT, DGIN, or DGOUT in order to synchronize input and output data.

This provides a simple way to synchronize all module polling with the foreground BASIC program loop. Synchronizing the background and foreground routines is important in order to determine the exact state of monitor and control points prior to allowing the foreground program to make any control decisions.

In the next example, the steps below take place in the order listed:

1. Local modules A & B and remote module 2B are defined.
2. The foreground BASIC program turns on RADIO polling based on Timer 1.
3. RADIO polling is instructed to stop so the foreground program will pause again if RADIO polling was enabled in line 62 until all communications with module 2B have been completed.

```
>LIST
10     DEFMOD 2B, DCM001 : REM DEFINE REMOTE MODULE
20     CHKTIMER 1 : POP TD1
22     IF (TD1=0) THEN POLLON : PUSH 15 : SETIMER 1
30     POLLOFF : REM STOP RADIO POLLING TO SYNCHRONIZE REMOTE I/O DATA

60     REM REMOTE I/O TRANSFER COMMANDS
  .
  .
  .
5000     GOTO 50 : REM RESTART POLLING LOOP

READY
>
```

POLLON Statement

Format: POLLON

Mode: Command; Run

Type: Control - Telemetry

This command enables background remote module polling and control point updating.

The function of the POLLON statement is to gather status from all hardware modules defined in the TCU, and update control points of defined modules appropriately. When executed, this function operates in the background and asynchronously to the program running in BASIC (refer to the POLLOFF statement for information on synchronizing background polling data with the foreground BASIC program running).

The primary use of the POLLON statement is to start the background REMOTE module polling and control point updating based on the modules defined with the DEFMOD statement. Module definition must be completed with the DEFMOD statement before executing the POLLON statement.

In the example below, the POLLON statement is used to enable RADIO polling functions. Since there are remote modules defined, RADIO polling is enabled by default.

```
>LIST
10     DEFMOD 2A, DMM001 : REM DEFINE LOCAL MODULE
30     POLLON : REM ENABLE REMOTE POLLING
40     POLLOFF : REM STOP POLLING TO SYNCHRONIZE I/O DATA

READY
>
```

IMPORTANT: Remote RTUs should not be polled more than once every 15 seconds to preserve battery life during power outages.

SYSCHECK Statement

Format: SYSCHECK { {r}M }

Mode: Command; Run

Type: Assignment - Telemetry

SYSCHECK can be used to determine the TCU's:

- EEProm status.
- Radio communications status with the central computer/server.
- Local module communications.
- Communications quality of remote modules when operating as the central.

The command line options are used only in the case of retrieving a remote module's communication status:

r := the remote station address (1 - 15)

M := the module address (A - O)

If no command line option is specified, this command places the system fault flags for central radio communications and EEProm status onto the argument stack in the following order:

1. RadFault
2. EEFault.

These values must be "POPped" (see the POP statement, page 39) off the argument stack (in reverse order) immediately after the SYSCHECK statement (see line 20 in the example below). All values except RadFault are logical (that is, 0 or 65535).

RadFault is used to indicate a radio link failure (no radio communication has occurred for 30 seconds) and has the following values.

- RadFault = 0 := No fault
- RadFault = 1 := Radio fault

The EE Prom fault indicates that a bad checksum was encountered in the EE Prom where the BASIC program is stored. An EE Prom fault will always be returned True when running a program located in the RAM. This is because a checksum is not generated for a program in RAM, but a checksum is generated for the program at the execution of an EPROG command when the program is stored in the EE Prom. [**Note:** If the EPROM in a TCU is reprogrammed, the EPROG statement must be executed to complete the chip program/installation. If an EPROG is not executed, an EE Prom fault occurs. If there is an existing program on the TCU and the EPROM has been replaced/reprogrammed, download the program into the TCU again and execute the EPROG command.]

SYSCHECK on Remote Modules

When a system check is performed on a remote module, the Off-line flag and the Link Performance Indicator (LPI) are placed on the argument stack. Remote modules go offline whenever 20 bad messages are received in a row. They will go back online when the next good message is received. The Offline Flag is equal to zero when communications are good. LPI is a relative number giving a long-term indication of the quality of the communications to that module. LPI provides a number between zero and 100 indicating the average percentage of good messages being received between each bad message.

The following example defines one remote module as station 2 module A. It then gets the Offline flag and Link Performance Indicator and prints them to the console.

```
>LIST
10     DEFMOD 2A,DCM001
100     POLLOFF RADIO
200     REM I/O STATEMENTS
        |
        |
500     POLLON RADIO
600     SYSCHECK 2A : POP COM2,LP2
610     IF COM2 THEN PRINT "OFFLINE", ELSE PRINT "ONLINE ",
620     PRINT USING(###), LP2,CR,
700     GOTO 100

READY
>RUN

ONLINE  90
```

SYSTIME Statement

Format: SYSTIME; SYSTIME SET

Mode: Command; Run

Type: Assignment - Telemetry

Without the "SET" option, this command gets the system time of day from the built-in battery-backed clock and places the values onto the argument stack. These values must be “POPped” (see the POP statement, page 39) off the argument stack immediately after the SYSTIME statement in the following order: Seconds, Minutes, Hours, Day, Date, Month, and Year (see line 10 in the example below).

All values are numeric:

- Seconds: 00 – 59
- Minutes: 00 – 59
- Hours: 00 – 23
- Day: 1 – 7 (Sunday=1)
- Date: 00 – 31
- Month: 00 – 12
- Year: 1900 – 9999 (the century must be included)

If the TCU is installed in a TACII system (where a Hyper SCADA Server or a central computer is used), the system time is automatically set through telemetry. It can also be set with the "SET" command line option as described below in cases where the TCU is being used independent of a Hyper SCADA Server/central computer, or is acting as the central site. Until then, all values will be zero, and the year will be set at 1900.

This example retrieves the system time and displays it to the console. If the year reads “1900,” this indicates that the onboard clock was never set or has failed.

```
>LIST
10     SYSTIME: POP SC, MN, HR, DY, DT, MO, YR
20     PRINT HR,":",MN,":",SC,"    ",MO,"/",DT,"/",YR,
30     IF (YR=1900) THEN PRINT “  CLOCK FAILED.”, ELSE PRINT SPC(15),
40     PRINT CR,

READY
>RUN

14:34:21  3/14/2002
```

The example below retrieves the system time and turns on a control point between 2:30pm and 3:00pm every day.

```
>LIST
10     TR=NOT(FA)
20     DEFMOD A,DCM001 :      REM DEFINE DIGITAL CONTROL MODULE
30     POLLON : POLLOFF
40     SYSTIME: POP SC,MN,HR,DY,DT,MO,YR
50     IF (HR=14).AND.(MN=30) THEN PUSH TR
52     IF (HR=15) THEN PUSH FA
54     DGOUT A1
60     GOTO 30
```

Setting the System Time

If the TCU is installed in a TACII system, the system time is initialized by telemetry from the Hyper SCADA Server or central computer via a radio link. However, if the TCU is used in a stand alone or central site mode, the time may be set with the "SET" command line option. In this situation, the time and date must be “PUSHed” (see PUSH statement, page 45) onto the argument stack prior to executing the SYSTIME SET statement (see line 140 in the example below).

This example adjusts the system time every spring and fall for daylight savings time. On the first Sunday of April, at 2:00 AM it adds one hour to the time. On the last Sunday of October, at 2:00 AM it subtracts one hour. The UPDATED logic variable makes sure that in the fall the hour is changed only once.

```
>LIST
10     TR=NOT(FA)
100     SYSTIME : POP SC,MN,HR,DY,DT,MO,YR
120     SPRING=(MO=4).AND.(DY=1).AND.(HR=2).AND.(DT<8)
122     FALL=(MO=10).AND.(DY=1).AND.(HR=2).AND.(DT>24).AND.NOT(UPDATED)
130     IF SPRING THEN HR=3
132     IF FALL THEN HR=1 : UPDATED=TR
134     IF (HR>2) THEN UPDATED=FA
140     IF (FALL.OR.SPRING) THEN PUSH SC,MN,HR,DY,DT,MO,YR : SYSTIME SET
150     GOTO 100
```

Notes:

Chapter 3: OPERATORS AND EXPRESSIONS

DFS BASIC-52 contains a complete set of arithmetical and logical operators. Operators are divided into two groups, dual operand, or dyadic, operators and single operand, or unary, operators.

DUAL OPERAND OPERATORS

Dual operand operators perform an operation on two variables to produce a single output. The generalized form of all dual operand instructions is [expr] OP [expr], where OP is either an arithmetic operator or a logical operator.

Arithmetic Operators

Exponentiation Operator

Format: [expr]**[expr]

This operator raises the first expression to the power of the second expression. The power any number can be raised to is limited to 255. The notation ** was chosen instead of the sometimes used “up arrow” symbol, because the " up arrow" symbol appears different on various terminals. To eliminate confusion, the ** notation was chosen.

```
PRINT 2**3
8
```

Multiplication Operator

Format: [expr]*[expr]

```
 PRINT 3*3
  9
```

Division Operator

Format: [expr]/[expr]

```
 PRINT 100/5
  20
```

Addition Operator

Format: [expr]+ [expr]

```
PRINT 3+2
5
```

Subtraction Operator

Format: [expr]-[expr]

```
PRINT 9-6
3
```

Logical Operators

These operators perform a bitwise logical function on valid integers. Both arguments for these operators must be between zero and 65535 (0FFFFH), inclusive. If an argument is outside of this range, DFS BASIC-52 returns a BAD ARGUMENT error. All non-integer values are truncated, ***not*** rounded.

The notation .OP. was chosen to increase readability. Without the "dots," or periods, around the names of operators, lines of code are difficult to read, because DFS BASIC-52:

- Eliminates ***all*** spaces when it processes a line of code.
- Inserts spaces before and after statements when it lists a user program.
- Does not insert spaces before and after operators.

As a result, a line entered as 10 B = A AND B would be listed as 10 B = AANDB. Adding dots to the logical instructions gives us 10 B = A.AND.B, which is easier to read.

AND Operator

Format: [expr].AND.[expr]

```
PRINT 3.AND.2
2
```

OR Operator

Format: [expr].OR.[expr]

```
PRINT 1.OR.4
5
```

Exclusive OR Operator

Format: [expr].XOR.[expr]

```
PRINT 7.XOR.6
1
```

UNARY OPERATORS

Unary, or single operand, operators perform an operation on a single variable to produce a single output. The generalized form of all single operand instructions is OP([expr]), where OP is either a general purpose or trigonometric function.

General Purpose Operators

Absolute Value Operator

Format: ABS([expr])

This operator returns the absolute value of the expression.

```
PRINT ABS(5)
5
PRINT ABS(-5)
5
```

E - Exponent Operator

Format: EXP ([expr])

This function raises the number "e" (2.7182818) to the power of the argument.

```
PRINT EXP (1)
2.7182818
PRINT EXP (LOG (2))
2
```

Integer Operator

Format: INT ([expr])

This operator returns the integer portion of the expression.

```
PRINT INT (3.7)
3
PRINT INT (100.876)
100
```

Logarithmic Operator

Format: LOG ([expr])

This operator returns the natural logarithm of the argument carried out to seven significant digits. The argument must be greater than zero.

```
PRINT LOG (12)
2.484906
PRINT LOG (EXP (1))
1
```

Not Operator

Format: NOT ([expr])

This operator returns a 16-bit one's complement of the expression. The expression must be a valid integer [that is, the expression must between zero and 65535 (0FFFFH), inclusive]. Non-integers are truncated, not rounded.

```
PRINT NOT (65000)
535

PRINT NOT (0)
65535
```

Random Number Operator

Format: RND

This operator returns a pseudo-random fractional number between zero and one, inclusive. The RND operator uses a 16-bit binary seed as an internal argument and generates 65536 pseudo-random numbers before repeating the sequence. The numbers generated are specifically between 0/65535 and 65535/65535 inclusive. Unlike most BASICS, the RND operator in DFS BASICS-52 does not require an argument or a dummy argument. In fact, if an argument is placed after the RND operator, a BAD SYNTAX error occurs.

```
>PRINT RND
 5.9510185 E-3
```

Sign Operator

Format: SGN ([expr])

This operator returns a value of:

- + 1 if the argument is greater than zero.
- 0 if the argument is equal to zero.
- - 1 if the argument is less than zero.

```
PRINT SGN (52)
1

PRINT SGN (0)
0

PRINT SGN (-8)
-1
```

Square Root Operator

Format: SQR ([expr])

This operator returns the square root value of the argument.

```
PRINT SQR (9)
3

PRINT SQR (45)
6.7082035

PRINT SQR (100)
10
```

Trigonometric Operators

The COS, SIN, and TAN operators use a Taylor series to calculate the function. These operators first reduce the argument to a value that is between zero and PI/2. This reduction is accomplished by the following equation:

Reduced Argument = (user arg/PI- INT (user arg/PI)) * PI

The reduced argument, from the above equation, will be between zero and PI. After the equation is calculated, the reduced argument is tested to see if it is greater than PI/2.

- If it is greater than PI/2, it is subtracted from PI to yield the final value.
- If it less than or equal to PI/2, the reduced argument is the final value.

Although this method of angle reduction provides a simple and economical means of generating the appropriate arguments for a Taylor series, there is an accuracy problem associated with this technique. The accuracy problem is noticed when the user argument is large (that is, greater that 1000). This occurs because significant digits in the decimal (fraction) portion of the reduced argument are lost in the expression (user arg/PI - INT (user arg/PI)). As a rule, try to keep the arguments for the TRIG functions as small as possible.

Arctangent Operator

Format: ATN ([expr])

This operator returns the ARCtangent of the argument (carried out to 7 significant digits) between - PI/2 and PI/2. The argument is expressed in radians and must be between +/- 200000. Note however that it is best to keep the argument between +/- 1000 for accuracy.

```
PRINT ATN (PI)
1.2626272

PRINT ATN (1)
.78539804
```

Cosine Operator

Format: COS ([expr])

This operator returns the COSine of the argument carried out to seven significant digits. The argument is expressed in radians and must be between +/- 200000. Note however that it is best to keep the argument between +/- 1000 for accuracy.

```
PRINT COS (PI/4)
.7071067

PRINT COS (0)
1
```

Sine Operator

Format: SIN ([expr])

This operator returns the SINe of the argument carried out to seven significant digits. The argument is expressed in radians and must be between +/- 200000. Note however that it is best to keep the argument between +/- 1000 for accuracy.

```
PRINT SIN (PI/4)
.7071067

PRINT SIN (0)
0
```

Tangent Operator

Format: TAN([expr])

This operator returns the TANgent of the argument. The argument is expressed in radians. Calculations are carried out to seven significant digits. The argument must be between +and - 200000, but is best kept between + and - 1000 for accuracy.

```
PRINT TAN (PI/4)
1

PRINT TAN (0)
0
```

UNDERSTANDING PRECEDENCE OF OPERATORS

The hierarchy of mathematics dictates that some operations are carried out before others. If you understand the hierarchy of mathematics, it is possible to write complex expressions using a minimum of parentheses. We will use the equation below to illustrate what precedence is all about.

4+3*2 = ?

Should you add (4+3) then multiply seven by 2, or should you multiply (3*2) then add 4 to 6? The hierarchy of mathematics says that multiplication has precedence over addition. In this example, 3 is multiplied by 2 first, and then 4 is added to the result of 3*2.

4+3*2 = 10

The rules for the hierarchy of math are simple. When an expression is scanned from left to right, an operation is not performed until an operator of lower or equal precedence remains to operate. In the example above, addition could not be performed because multiplication has higher precedence.

The precedence of operators from highest to lowest in DFS BASIC-52 is as follows:

1. Operators that use parentheses ( )
2. Exponentiation (**)
3. Negation (-)
4. Multiplication (*) and division (/)
5. Addition (+) and subtraction (-)
6. Relational expressions (=, <>, >, >=, <, <=)
7. Logical and (.and.)
8. Logical or (.or.)
9. Logical xor (.xor.)

Relative to operator precedence, the rule of thumb should always be – when in doubt, use parentheses.

HOW RELATIONAL EXPRESSIONS WORK

Relational expressions involve the following operators:

= (equal to)	<> (not equal to)
> (greater than)	>= (greater than or equal to)
< (less than)	<= (less than or equal to)

These operators are typically used to "test" a condition. In DFS BASIC-52, relational operators return a result of:

- 65535 (0FFFFH) if the relational expression is true.
- zero if the relation expression is false.

The result returned is returned to the argument stack when used with a statement that can manipulate the argument stack (for example, PRINT or PUSH). This makes it possible for you to display the result of a relational expression.

```
PRINT 1=0
0

PRINT 1>0
65535

PRINT A<>A
0

PRINT A=A
65535
```

Having a relational expression actually return a result offers a unique benefit in that relational expressions can actually be "chained" together using the logical operators .AND., .OR., and .XOR.. This allows you to test a rather complex condition with a single line of code.

```
10 IF A<B .AND. A>C .OR. A>D THEN.......
```

Additionally, the NOT([expr]) operator can be used.

```
10 IF (NOT(A>B)).AND.(A<C) THEN.........
```

When using logical operators to link together relational expressions, it is very important that you pay careful attention to the precedence of operators. The logical operators were assigned lower precedence, relative to relational expressions, to make the linking of relational expressions possible without using parentheses. However, it is suggested that parenthesis be used in most cases, regardless of precedence of operators, to help eliminate calculation errors on the programmer's part.

STRINGS AND STRING OPERATORS

A string is a single character or a series of characters that are stored in memory. Usually, the characters stored in a string make up a word or a sentence. Strings are most useful in DFS BASIC-52 when manipulating the TCU's MENU display. Refer to the MENU statement (p. 31) in Chapter 2: Commands and Statements for more information.

DFS BASIC-52 contains one-dimensioned string variables {$([expr])}. The dimension of the string variable (the [expr] value) ranges from zero to 254. This allows you to define and manipulate 255 different strings. Initially, ***no*** memory is allocated for strings. Memory is allocated by the STRING [expr], [expr] statement. The details of this statement are covered on page 50 Chapter 2: Commands and Statements.

In DFS BASIC-52, a string can be defined with the INPUT statement or the LET statement.

```
>LIST
10     STRING 100,20
20    $(1)="THIS IS A STRING "
30     INPUT "WHAT'S YOUR NAME? ",$(2)
40     PRINT $(1),$(2)

READY
>RUN

WHAT'S YOUR NAME? FRED
THIS IS A STRING FRED

READY
>
```

STRINGS can also be assigned to each other with a LET Statement. Here the value in $(1) is assigned to $(2).

```
$(2) = $(1)
```

String Operators

DFS BASIC-52 features two operators that can be used to manipulate STRINGS: ASC ( ) and CHR ( ). By using the string operators available in DFS BASIC-52, it is possible to manipulate strings in almost any way imaginable.

ASCII Operator

Format: ASC( )

The ASC( ) operator returns the integer value of the ASCII character placed in the parentheses. The number 65 is the decimal representation for the ASCII character "A".

```
>PRINT ASC(A)
 65
```

In addition, individual characters in a predefined ASCII string can be evaluated with the ASC( ) operator. The $([expr]) denotes what string is being accessed. The expression after the comma selects an individual character in the string.

In the first example below, the first character in the string was selected (84 is the decimal representation for the ASCII character "T"). The second example shows the beginning sequence of the alphabet.

```
>LIST10
STRING 100,2020
$(1)="THIS IS A STRING "30
PRINT ASC($(1),1)
```

(continued on next page…)

```
READY
>RUN

THIS IS A STRING 84
```

```
>LIST
10     STRING 100,20
20    $(1)="ABCDEFGHIJKL"
30     FOR X=1 TO 12
40     PRINT ASC($(1),X),
50     NEXT X

READY
>RUN

65  66  67  68  69  70  71  72  73  74  75  76
```

In general, the ASC( ) operator lets the programmer manipulate individual characters in a string.

```
>LIST
10     STRING 100,20
20    $(1)="ABCDEFGHIJKL"
30     PRINT $(1)
40     ASC($(1),1)=75
50     PRINT $ (1)
60     ASC($(1),2)=ASC($(1),3)
70     PRINT $(1)

READY
>RUN

ABCDEFGHIJKL
KBCDEFGHIJKL
KCCDEFGHIJKL
```

A simple program can determine if two strings are identical.

```
>LIST
10     STRING 100,20
20    $(1)="SECRET" : REM ‘SECRET’ IS THE PASSWORD
30     INPUT "WHAT'S THE PASSWORD? ",$(2)
40     FOR X=1 TO 6
50     IF ASC($(1),X)=ASC($(2),X) THEN NEXT X ELSE 80
60     PRINT "YOU GUESSED IT!"
70     END
80     PRINT "WRONG TRY AGAIN" : GOTO 30
```

(continued on next page…)

```
READY
>RUN

WHAT'S THE PASSWORD? SECURE
WRONG, TRY AGAIN
WHAT'S THE PASSWORD? SECRET
YOU GUESSED IT!

READY
>
```

Character Operator

Format: (CHR( ))

The CHR( ) operator is the converse of the ASC( ) operator. It converts a numeric expression to an ASCII character. The expressions contained within the parentheses have the same meaning as the expressions in the ASC( ) operator. Unlike the ASC( ) operator, however, the CHR( ) operator ***cannot*** be assigned a value. A statement such as CHR($(1),1) = H, is invalid and generates a BAD SYNTAX error. Use the ASC( ) operator to change a value in a string. The CHR( ) operator can only be used within a PRINT statement. The example below illustrates how the CHR( ) can be used.

```
>LIST
10     STRING 100,20
20    $(1)="DFS BASIC-52"
30     FOR X=1 TO 12 : PRINT CHR($(1),X), : NEXT X
40     PRINT : FOR X=12 TO 1 STEP -1
50     PRINT CHR ($(1),X), : NEXT X

READY
>RUN

DFS BASIC-52
25-CISAB SFD

READY
>
```

Clear Screen & Cursor “Home” Print Statements

In a print statement, either typed in Command mode or executed in Run mode, the CHR( ) operator can be used to clear the console display screen and position the cursor at the top left corner of the screen (the “home” position).

- The character “27” is the ASCII decimal equivalent to the Escape command sequence.
- The “[2J” sequence is the VT100 clear screen command.
- The “[H” sequence is the VT100 cursor home command. When printed in this format, the VT100 command is assigned to execute with the next carriage return (or in this case, at the completion of the PRINT Statement).

To clear the screen, use this statement in Command or Run mode:

PRINT CHR(27),"[2J",

To position the cursor "home," use this statement in Command or Run mode:

PRINT CHR(27),"[H",

SPECIAL FUNCTION OPERATORS

Special function operators directly manipulate the I/O hardware and the memory addresses on the 8052AH device. All special function operators, with the exception of CBY([expr]) and GET, can be placed on either side of the replacement operator (=) in a LET Statement.

DBY ([expr])

The DBY ([expr]) operator is used to retrieve or assign a value to the 8052AH's internal data memory. Both the value and argument in the DBY operator must be between zero and 255, inclusive, because there are only 256 internal memory locations in the 8052AH and one byte can only represent a quantity between zero and 255, inclusive.

The first example below assigns the value in internal memory location B to variable A. The second example loads internal memory location 250 with the same value in program memory location 1000.

```
A=DBY (B)
```

```
DBY(250)=CBY(1000)
```

GET

The GET operator only produces a meaningful result when used in Run mode. It will always return a result of zero in Command mode. GET takes a "snapshot" of the console input device. If a character is available from the console device, the value of the character is assigned to GET. After GET is read in the program, GET is assigned the value of zero until another character is sent from the console device. This implementation guarantees that the first character entered will always be read, independent of where the GET operator is placed in the program.

The following example prints the decimal representation of any character typed at the console (the sequence of keys pressed was 'D', 'F', 'S', <space bar>, '5', and '2' followed by (Ctrl) C).

```
>LIST
10    A=GET
20     IF (A<>0) THEN  PRINT A,
30     GOTO 10

READY
>RUN

 68  70  83  32  53  50
```

(continued on next page…)

```
STOP - IN LINE  20
READY
>

)=DBY(100)
```

XBY

Format: XBY([expr])

The XBY operator is used to retrieve or assign a value to the 8052AH's external data memory. The argument in the XBY([expr]) operator must be a valid integer [that is, an integer between zero and 65535 (0FFFFH)]. The value assigned to the XBY([expr]) operator must be between zero and 255. A value outside this range generates a BAD ARGUMENT error.

In this example, the variable A is set equal to the value in external memory location 0F000H.

```
A=XBY(0F000H)
```

This example loads external memory location 4000H with the same value that is in internal memory location 100.

```
XBY(4000H)=DBY(100)
```

System Control Values

System control values determine or reveal how memory is allocated by DFS BASIC-52. Unlike some BASICS, DFS BASIC-52 does not require any "dummy" arguments for the system control values.

FREE

The system control value FREE tells you how many bytes of RAM are available to the user. When the current selected program is in RAM, the following relationship always holds true.

FREE = MTOP - LEN - 511

```
>PRINT FREE
19952
```

LEN

The system control value LEN indicates how many bytes of memory the current selected program occupies. LEN can only be read; it cannot be assigned a value. A NULL program returns a LEN of 1 (one), which represents the end of program file character. There is typically 20K-Bytes of available memory in RAM for program and data storage during program execution.

```
>PRINT LEN
85
```

MTOP

After reset, DFS BASIC-52 sizes the external memory and assigns the last valid memory address to the system control value MTOP. DFS BASIC-52 will not use any external RAM beyond the value assigned to MTOP. If MTOP is assigned a value that is greater than the last valid memory address, a MEMORY ALLOCATION error is generated.

```
>PRINT MTOP
20464
```

ERROR MESSAGES

DFS BASIC-52 has a relatively sophisticated error processor. When BASIC is in Run mode, the generalized form of an error message is as follows:

```
ERROR:  XXX - IN LINE YYY
YYY BASIC STATEMENT
-----------X
```

XXX represents the error type, and YYY is the line number in which the error occurred. A specific example is:

```
ERROR:  BAD SYNTAX - IN LINE 10
10 PRINT 34*21*
--------------X
```

The X signifies approximately where in the line number the error occurred. The specific location of the X may be off by one or two characters or expressions depending on the type of error and where the error occurred in the program. If an error occurs in Command mode, only the error type is printed; the line number is ***not*** printed. This occurs because there are no line numbers in Command mode.

Error types are described in the sections that follow.

A-Stack

An A-STACK (argument stack) error occurs when the argument stack pointer is forced "out of bounds." This can happen if the user overflows the argument stack by “PUSHing” too many expressions onto the stack, or by attempting to POP data off the stack when no data is present.

Array Size

If an array is dimensioned with a DIM statement (or defaults to a dimension of 10 without the use of the DIM statement) and an attempt is made to access a variable that is outside of the dimensioned bounds, an ARRAY SIZE error is generated.

Arith. Overflow

Error Code: 20

See ONERR Statement (page 38) in Chapter 2: Commands and Statements.

If the result of an arithmetic operation exceeds the upper limit of a DFS BASIC-52 floating point number, an ARITH. OVERFLOW error occurs. The largest floating-point number in DFS BASIC-52 is + 1E127, where E represents power or exponent.

Arith. Underflow

Error Code: 30

See ONERR Statement (page 38) in Chapter 2: Commands and Statements.

If the result of an arithmetic operation exceeds the lower limit of a DFS BASIC-52 floating point number, an ARITH. UNDERFLOW error occurs. The smallest floating-point number in DFS BASIC-52 is -1E127, where E represents power or exponent.

Bad Argument

Error Code: 40

See ONERR Statement (page 38) in Chapter 2: Commands and Statements.

When the argument of an operator is not within the limits of the operator, a BAD ARGUMENT error is returned. For instance, DBY (257) would generate a BAD ARGUMENT error because the argument for the DBY operator is limited to the range 0 to 255. Similarly, XBY(500H) = - 1 would generate a BAD ARGUMENT error because the value of the XBY operator is limited to the range 0 to 255.

Bad Syntax

A BAD SYNTAX error is generated if:

- The program contains an invalid DFS BASIC-52 command, statement, or operator that BASIC cannot process.
- A reserved keyword is used as part of a variable.

If you receive a BAD SYNTAX error, verify that everything was typed in correctly and that no keywords have been used in variables.

C-Stack

A C-STACK (control stack) error occurs if the control stack pointer is forced "out of bounds." There are only 158 bytes of external memory allocated for the control stack.

- FOR--NEXT loops require 17 bytes of control stack memory.
- DO--UNTIL, DO--WHILE, and GOSUB--RETURN loops require three bytes of control stack memory.

If more memory was used than the allocated control stack memory, DFS BASIC-52 generates a C-STACK error.

Additionally, a C-STACK error occurs if:

- A RETURN is executed before a GOSUB, a WHILE or UNTIL before a DO, or a NEXT before a FOR.
- A STRING command is placed in a subroutine.

Can't Continue

Program execution can be halted by either typing in a (Ctrl) C to the console device or by executing a STOP statement. Normally, program execution can be resumed by typing in the CONT command. However, if the user edits the program after halting execution and then enters the CONT command, a CAN'T CONTINUE error is generated. A (Ctrl) C must be typed during program execution or a STOP statement must be executed before the CONT command will work.

Divide By Zero

Error Code: 10

See ONERR Statement (page 38) in Chapter 2: Commands and Statements.

Attempting a division by 0 (zero) (for example, 12/0) causes a DIVIDE BY ZERO error.

Extra Ignored

This error occurs when a string that is larger than the size allocated by the STRING statement is assigned to a string variable. The EXTRA IGNORED message prints to the screen while the program is running, but does not stop program execution. Typically, this will not cause a problem with the operation of the program except for the display of the string assigned to the string variable (the string will be truncated to the number of characters allocated in memory by the STRING statement). However, if the TCU is utilizing the MODBUS feature, communications between the TCU and the connected device will fail when the EXTRA IGNORED error message prints to the host port.

I-Stack

An I-STACK (internal stack) error occurs when DFS BASIC-52 does not have enough stack space to evaluate an expression. Normally, I-STACK errors will not occur unless insufficient memory has been allocated to the 8052AH's stack pointer.

Illegal Direct

Some statements, such as IF-THEN and DATA, cannot be executed while the DFS BASIC-52 device is in Command mode. If you attempt to execute one of these statements, the message ERROR: ILLEGAL DIRECT is printed to the console device.

Invalid Menu Option

This error is generated when one of the MENU commands is used with a parameter outside of the 1-16 menu range. For example “PUSH 18 : MENU” is invalid since there are only 1-16 menu options.

Line Too Long

If you type a line that contains more than 79 characters, DFS BASIC-52 will echo a bell character to the user terminal. DFS BASIC-52's input buffer can handle a maximum of 79 characters.

Memory Allocation

A MEMORY ALLOCATION error occurs if:

- An attempt is made to access STRINGS that are "outside" the defined string limits.
- The system control value MTOP is assigned a value that does not contain any RAM memory.

No Data

The message ERROR: NO DATA ---IN LINE XXX is printed to the console device if:

- A READ statement is executed and no DATA statement exists.
- All DATA has been read and a RESTORE instruction was not executed.

Programming

If an error occurs while the DFS BASIC-52 device is programming an EPROM, a PROGRAMMING error is generated. An error encountered during programming destroys the EPROM file structure. As a result, no more programs can be saved on that particular EPROM once a PROGRAMMING error occurs.

ANOMALIES

Most dictionaries define an anomaly as a deviation from the normal or common order or as an irregularity. Anomalies to an extreme become "bugs," or something that is wrong with the program. Like all programs, DFS BASIC-52 contains some anomalies. The purpose of mentioning the known anomalies is that it may save you some time should unexpected things happen during program execution. The known anomalies deal mainly with the way DFS BASIC-52 compacts or tokenizes the BASIC program.

1. When using the variable H after a line number, make sure you put a space between the line number and the H. If the space is omitted, BASIC will assume that the line number is a HEX number. Note that a TAB character is not sufficient because it will be stripped out by the BASIC interpreter.

```
>20H=10  (WRONG)

>LIST
32     =10

>20 H=10   (RIGHT)

>LIST
20     H=10
```

2. When using the variable I before an ELSE statement, make sure you put a space between the I and the ELSE statement. If the space is omitted, BASIC will assume that the IE portion of IELSE is the special function operator IE.

```
>20   IF I>10 THEN PRINT IELSE 100

 >LIST
 20   IF I>10 THEN PRINT IE  LSE 100    (WRONG)

 >20 IF I>10 THEN PRINT I  ELSE 100

 >LIST
 20    IF I>10 THEN PRINT I ELSE 100   (RIGHT)
```

3. A space character cannot be placed inside the ASC( ) operator. For example, the statement PRINT ASC( ) yields a BAD SYNTAX error. Spaces may be placed in strings, however, so a statement like the following will work properly:

```
LET $(1) = "HELLO, HOW ARE YOU"
PRINT ASC($(1),1)
```

The reason ASC( ) yields an error is that DFS BASIC-52 eliminates all spaces when a line is processed, so ASC( ) will be stored as ASC( ) and DFS BASIC-52 interprets this as an error.

4. Variables can be up to eight characters in length. However, only the first character, the last character, and the total number of characters are of significance. This allows the user to better describe variables that are used in a program. Details on the limitations of expanded variables can be found in Chapter 1: Definition of Terms beginning on page 6.

5. When using the IF--THEN Statement with an expanded logical variable instead of an expression, always place parenthesis around the condition variable(s). Otherwise, the variable name may be truncated while tokenizing.

```
>LIST
10 PRES_OK=(PRESS>100)
15 REM *** WRONG ***
20 IF PRES_OK THEN 100
30 IF (PRES_OK).AND.(X>5) THEN (PRES=X*100)

>LIST
10 PRES_OK=(PRESS>100)
15 REM *** RIGHT ***
20 IF (PRES_OK) THEN 100
30 IF (PRES_OK).AND.(X>5) THEN PRES=(X*100)
```

6. When creating variable names, beware of using imbedded reserved key words. In the example below, three key words are found imbedded in variable names: TO, P., and ON. Also, note what happens when a space instead of an equals sign, colon, or parenthesis is used after the letter F in a variable name (see HALF in the first line below).

```
>10 IF (TOP.AND.BOTTOM) THEN FULL=HALF ELSE FULL=NONE   (WRONG)
>LIST
10     IF ( TO PRINT AND.BOT TO M) THEN FULL=HAL ELSE FULL=N ON E

>10 IF (TP).AND.(BOT) THEN FULL=(HALF) ELSE FULL=(NUN)  (RIGHT)
```

Appendix A: RESERVED KEYWORDS

ABS	FPROG	ONEX1	RETURN
AND	FPROG1	ONTIME	RND
ANIN	FPROG2	OR	ROM
ANOUT	FPROG3	P.	RROM
ASC	FPROG4	PCON	RUN
ATN	FPROG5	PGM	SETIMER
BAUD	FPROG6	PH0.	SGN
CALL	FREE	PH0.#	SIN
CBY	GET	PH0.@	SQR
CHKTIMER	GOSUB	PH1.	ST@
CHR	GOSUB	PH1.#	STEP
CLEAR	GOTO	PH1.@	STOP
CLEARI	HOST	PI	STRING
CLEARS	IDLE	POLLOFF	SYSCHECK
CLOCK	IE	POLLON	SYSTIME
CLOCK0	IF	POP	T2CON
CLOCK1	INPUT	PORT1	TAN
CLR	INT	PRINT	TCON
CONT	IP	PRINT#	THEN
COS	LD@	PRINT@	TIME
COS	LEN	PROG	TIMER0
CR	LET	PROG1	TIMER1
DATA	LIST	PROG2	TIMER2
DBY	LIST#	PROG3	TMOD
DEFMOD	LIST@	PROG4	TO
DGIN	LOCAL	PROG5	UI0
DGOUT	LOG	PROG6	UI1
DIM	LPI	PUSH	UNTIL
DO	MENU	PWM	UO0
DUMMY	MTOP	RADIO	WHILE
ELSE	NEW	RAM	XBY
END	NEXT	RCAP2	XFER
EPROG	NULL	READ	XOR
ERASE	OFF	REM	XTAL
EXP	ON	RESTORE	
FOR	ONERR	RETI	

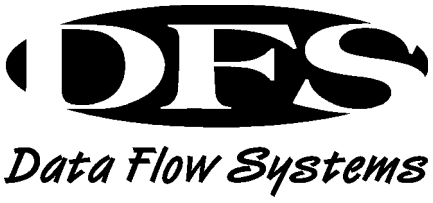
Notes

Appendix B: FREE EXTERNAL MEMORY STORAGE MAP

The following memory locations are the 168 available non-volatile RAM locations usable for storing set point variables. Each location is listed with its most and least significant byte for clarity. The PLC memory editor points to the most significant byte and the PLC points to the least significant byte using the LD@ Statement (i.e., LD@(5005H)). This table is provided as a utility to help organize set point variables during program development (hint: make copies as necessary).

5000-5005	5006-500B	500C-5011	5012-5017	5018-501D	501E-5023	5024-5029	502A-502F
5030-5035	5036-503B	503C-5041	5042-5047	5048-504D	504E-5053	5054-5059	505A-505F
5060-5065	5066-506B	506C-5071	5072-5077	5078-507D	507E-5083	5084-5089	508A-508F
5090-5095	5096-509B	509C-50A1	50A2-50A7	50A8-50AD	50AE-50B3	50B4-50B9	50BA-50BF
50C0-50C5	50C6-50CB	50CC-50D1	50D2-50D7	50D8-50DD	50DE-50E3	50E4-50E9	50EA-50EF
50F0-50F5	50F6-50FB	50FC-5101	5102-5107	5108-510D	510E-5113	5114-5119	511A-511F
5120-5125	5126-512B	512C-5131	5132-5137	5138-513D	513E-5143	5144-5149	514A-514F
5150-5155	5156-515B	515C-5161	5162-5167	5168-516D	516E-5173	5174-5179	517A-517F
5180-5185	5186-518B	518C-5191	5192-5197	5198-519D	519E-51A3	51A4-51A9	51AA-51AF
51B0-51B5	51B6-51BB	51BC-51C1	51C2-51C7	51C8-51CD	51CE-51D3	51D4-51D9	51DA-51DF
51E0-51E5	51E6-51EB	51EC-51F1	51F2-51F7	51F8-51FD	51FE-5203	5204-5209	520A-520F
5210-5215	5216-521B	521C-5221	5222-5227	5228-522D	522E-5233	5234-5239	523A-523F
5240-5245	5246-524B	524C-5251	5252-5257	5258-525D	525E-5263	5264-5269	526A-526F
5270-5275	5276-527B	527C-5281	5282-5287	5288-528D	528E-5293	5294-5299	529A-529F
52A0-52A5	52A6-52AB	52AC-52B1	52B2-52B7	52B8-52BD	52BE-52C3	52C4-52C9	52CA-52CF
52D0-52D5	52D6-52DB	52DC-52E1	52E2-52E7	52E8-52ED	52EE-52F3	52F4-52F9	52FA-52FF
5300-5305	5306-530B	530C-5311	5312-5317	5318-531D	531E-5323	5324-5329	532A-532F
5330-5335	5336-533B	533C-5341	5342-5347	5348-534D	534E-5353	5354-5359	535A-535F
5360-5365	5366-536B	536C-5371	5372-5377	5378-537D	537E-5383	5384-5389	538A-538F
5390-5395	5396-539B	539C-53A1	53A2-53A7	53A8-53AD	53AE-53B3	53B4-53B9	53BA-53BF
53C0-53C5	53C6-53CB	53CC-53D1	53D2-53D7	53D8-53DD	53DE-53E3	53E4-53E9	53EA-53EF

Notes



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