Auxiliary Function PROM (Cat. No. 1772-AF4) for the Mini–PLC–2/15 Controller

User Manual

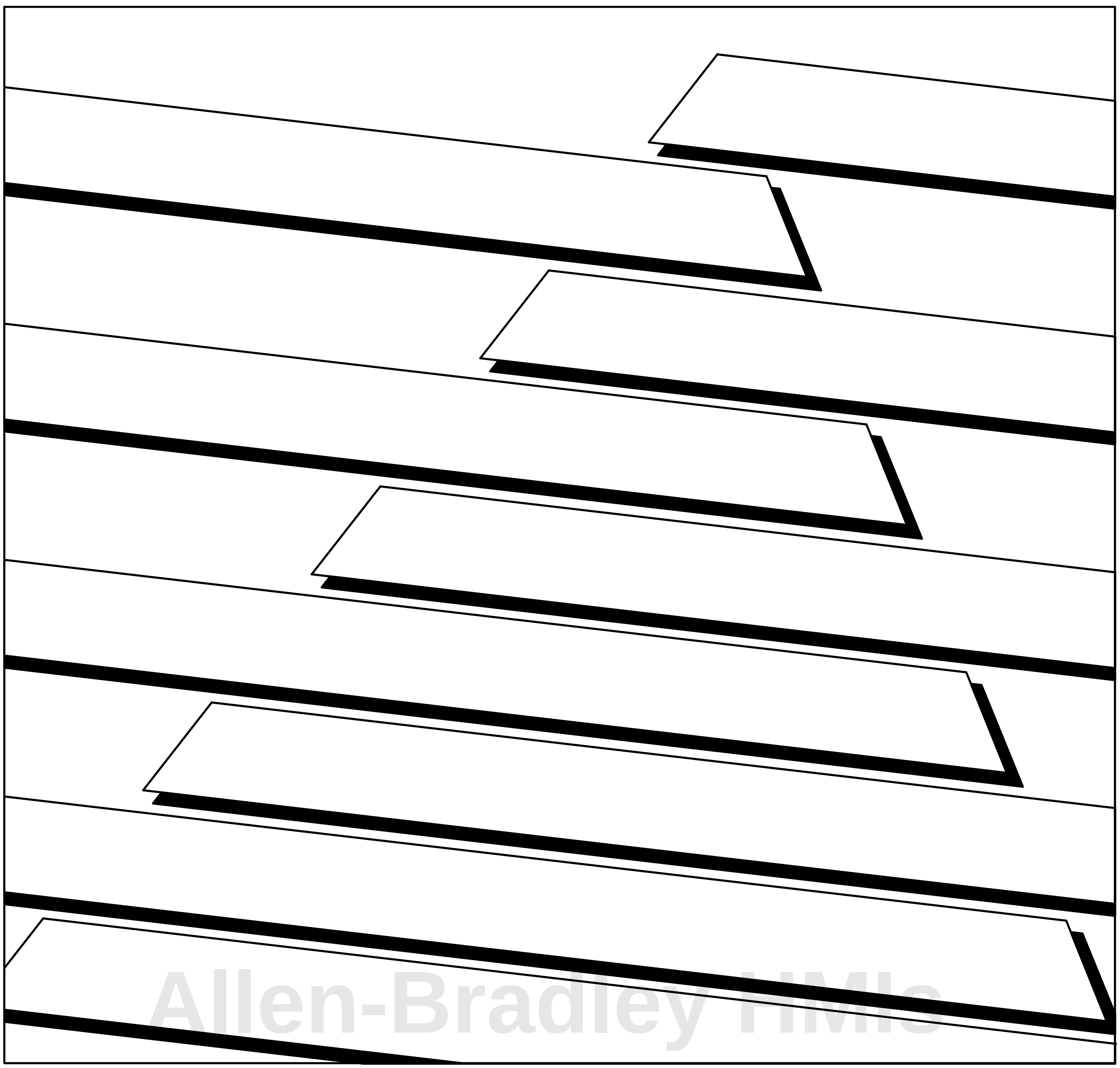


Table of Contents

Chapter 1

Introduction

General

Installation of the Auxiliary Function (AF) PROM (cat. no. 1772-AF4 in your Mini-PLC-2/15 controller lets you expand its mathematical capabilities.

For simplification, throughout this manual we refer to the Auxiliary Function PROM (cat. no. 1772-AF4) as the AF4.

The AF4 can only be used with the series A Mini-PLC-2/15 processor module, firmware revision 11 or later (cat. no. 1772-LV). The AF4 can only be used with the series B Mini-PLC-2/15 processor module, firmware revision 4 or later. Programming the AF4 functions with either series Mini-PLC-2/15 processor module requires the Industrial Terminal (cat. no. 1770-T3).

The AF4 has a 2K (16 bit) word section to which you can transfer your program (for backup memory) and a 2K word section for higher mathematical functions. You can only transfer your program into the AF4 with the series B PLC-2/15 controller (Table 1.A). Series A Mini-PLC-2/16 Processor EPROM (publication 1770-91) describes program transfer to PROM. With the series A PLC-2/15 controller, program transfer to the AF4 is not possible.

Table 1.A
AF4 PROM Response Controller

Mini-PLC-2/15 Controller Series	User Program 2K Words		
	Read	Write	Erase [1]
A	Yes	No	No
B	Yes	Yes	No

[1] You can erase the 2K memory backup portion of the AF4 with ultraviolet light. However, the 2K section for higher mathematical functions would also be erased and all AF1 function capabilities lost. Once erased, the AF4 functions are irretrievable.

NOTE: The AF4 is sensitive to ultraviolet (UV) light, therefore when exposed to UV light, both the program and the auxiliary functions are erased. The AF4's transparent window is covered with the product label to avoid accidental alteration of memory from ultraviolet light sources. Do not remove this label.

Functions

The AF4 performs the following arithmetic functions:

- Six digit add and subtract
- Six digit multiply and divide
- BCD to binary conversion
- Binary to BCD conversion
- Logarithm of a three digit number to the base 10
- Logarithm of a three digit number to the base 3
- Exponential function $-e^{\pm X}$
- Power function $-y^{\pm X}$
- Reciprocal of a number - $\frac{1}{\pm X}$
- Sine of an angle - sin X
- Cosine of an angle - cos X
- Square root of a number $-x^{0.5}$

Applications

These arithmetic functions have applications in various industries such as food processing, machine tool work, and material handling. Applications in these industries could be weighing, blending, batch processing, scaling, positioning, test stands, and heat treating. The square root function is frequently used for flow measurement and in mining applications.

Manual's Purpose

This manual shows you how to install and program the AF4 in your Mini-PLC-2/15 controller.

Audience

We assume that you are familiar with programming and operation of the Mini-PLC- 2/15 and the Industrial Terminal (cat. no. 10770-T3). If this is not the case, refer to the appropriate publications or see our Publication Index (publication SD499).

WARNING: : Use only Allen-Bradley authorized programming devices to program Allen-Bradley programmable controllers. Using unauthorized programming devices may result in unexpected operation, possibly causing equipment damage and/or injury to personnel.

Chapter 2

Installation

General

During AF4 installation, take special care not to bend or contaminate the pins. Bent or dirty pins can prevent proper AF4 programming and use. The AF4's transparent window is covered with the product label to avoid accidental alteration of memory from UV light sources. Do not remove this label. Store the AF4 in its shipping container when not installed in a Mini-PLC-2/15 processor.

Installation/Removal Handling Instructions

The AF4 can be damaged during routine handling if proper precautions are not taken to reduce static electricity discharges.

Recommended precautions include:

- Handle the AF4 by the case without touching its pins.
- Use a static free work station.
- Wear a conductive wrist strap which has a minimum 200k ohms resistance and is connected to earth ground.
- Ground tools prior to contacting the AF4.
- Connect static-free work station to ground through a minimum 200k ohm resistance.
- Control the relative humidity of the installation area - ideal conditions are 40% to 60% relative humidity.

The following is a list of things that should not be done:

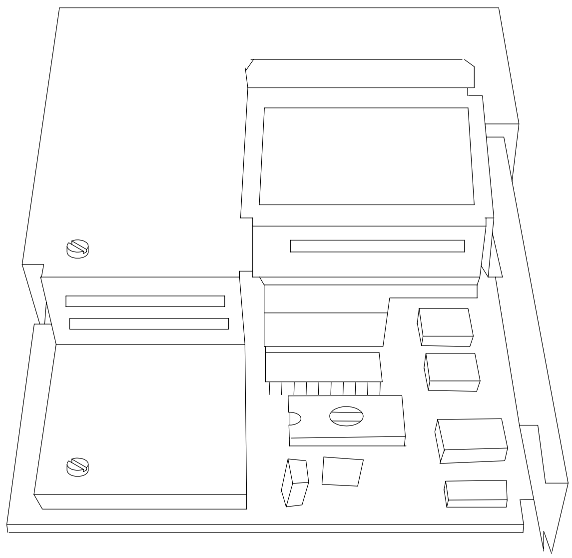
- Do not handle styrofoam, plastic, or cellophane-covered articles such as combs, cigarette packages, and candy immediately prior to handling an AF4.
- Do not hand the AF4 to someone who is not antistatic protected.
- Do not install the AF4 in areas which might contaminate or foul the pins of the AF4 device.
- Do not handle the AF4 by its pins.
- Do not slide the AF4 across any surface.
- Do not place the AF4 in a non-conductive plastic bag.

When these precautions are followed, the potential difference between the AF4 pins is reduced thereby reducing the problems associated with static discharges.

Installation

The AF4 fits into a 28-pin ZIF (zero insertion force) socket, which is located under a hinged door at the lower side of the Mini-PLC-2/15 processor (Figure 2.1).

Figure 2.1
PROM Socket



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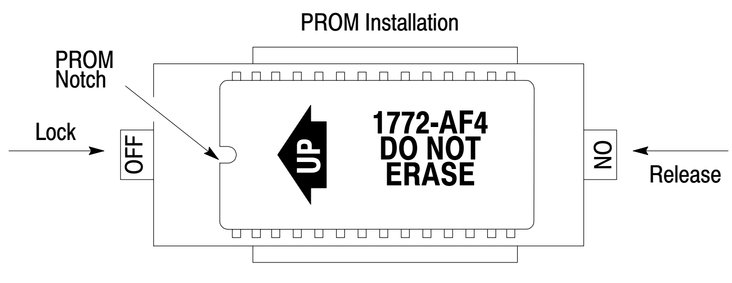
On the underside of the PROM door is a label that illustrates PROM installation. The notch on the AF4 PROM, when installed, must correspond to the notch shown on the label. Figure 2.2 shows a properly installed AF4.

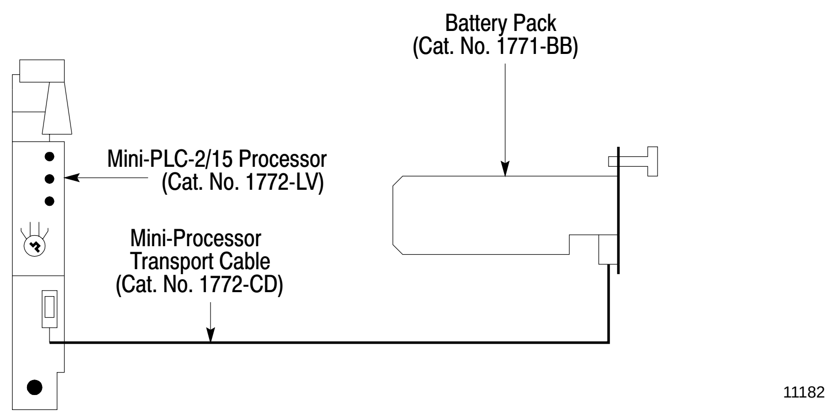
Figure 2.2
AF4 Installed



11590

To access the PROM socket, remove the Mini-PLC-2/15 processor module from the I/O chassis. If you desire to maintain processor memory contents, connect an external battery pack (Figure 2.3) to the processor with the Mini-Processor Transport Cable (cat. no. 1772-CD) prior to removing the module from the chassis.

Figure 2.3
External Battery Backup



To install the AF4, perform the following steps (Figure 2.2):

1. Turn the mode select switch to PROG.

2. Remove AC power from the I/O chassis power supply.

3. Remove the processor module from the I/O chassis.

4. Check all AF4 pins to ensure they are not bent or dirty.

5. Loosen the screw and lift the PROM door.

6. Push the ON tab in to unlock the socket.

7. Position the AF4 as shown in Figure 2.2. Be sure the notch on your AF4 faces the OFF tab.

8. Line up the AF4 as shown in Figure 2.2 and seat in the socket. Be sure the pins are aligned as they bend easily.

9. Lock the AF4 in place by pushing the OFF tab in.

10. Close the PROM door and tighten the screw.

Removal

To remove the AF4, perform the following steps:

1. Turn the mode select switch to PROG.
2. To maintain processor memory contents connect an external battery pack to the processor with the mini-processor transport cable (Figure 2.3).
3. Remove AC power from the I/O chassis power supply.
4. Remove the processor module from the I/O chassis.
5. Loosen the screw, lift up the PROM door, and push the ON tab in to unlock the socket (Figure 2.2).
6. Carefully remove the AF4 and store it in its shipping container.

Chapter 3

Programming

General

You access the AF4 by pressing [SHIFT][EAF] (execute auxiliary function) or [SHIFT][SCT] on the keyboard of your Industrial Terminal (cat. no. 1770-T3). The instruction is an output instruction and may be preceded on a rung by condition instructions. Once you enter the function, the block diagram of Figure 3.1 appears on the CRT. To program a specific mathematics functions, you would enter the appropriate function number (Table 3.A). If you enter a non-existent function number, the following occurs:

When the processor attempts to execute a function number which does not exist on the AF4, the response of the processor depends upon whether the keyswitch is in the RUN or RUN/PROGRAM position.

The responses are:

In the RUN position, the processor stops running and the CRT displays PROCESSOR FAULT and CHANGE PROCESSOR TO PROGRAM MODE. The processor and memory LEDs illuminate. After you change processor operation to program mode the LEDs turn off and the CRT displays MODE SELECTION menu and PLC-2 RUN TIME ERROR, PRESS 11 TO CONTINUE. When you press 11 the CRT displays and intensifies the rung containing the illegal opcode and states ILLEGAL OPCODE INTENSIFIED INSTRUCTION LINKED WITH CAUSE OF ERROR.

In the RUN/PROGRAM position, the processor stops running and the CRT displays MODE SELECTION menu and PLC-2 RUN TIME ERROR, PRESS 11 TO CONTINUE. When you press 11 the CRT displays and intensifies the rung containing the illegal opcode and states ILLEGAL OPCODE INTENSIFIED INSTRUCTION LINKED WITH CAUSE OF ERROR.

Table 3.A
Function Numbers for the AF4

Function Number	Mathematical Operation
01	Add
02	Subtract
03	Multiply
04	Divide
13	BCD to Binary conversion
14	Binary to BCD conversion
30	Log to base 10
31	Natural log (log to base e)
32	Exponential
33	Power
34	Reciprocal
35	Sine
36	Cosine
37	Square Root

You enter an existent function number and then enter data and result addresses (we will explain this in detail later). The processor then places a number in the data address.

AF4 Function Sequence

When the Mini-PLC-2/15 controller encounters an AF4 function during program execution and the rung is true, the processor performs the following steps:

1. Saves its present position in the user program.
2. The interlock system grants access to the AF4 function.
3. Reads the operand’s data stored in the data address that you entered.
4. Reads the result address which you entered.
5. Determines the location of the mathematical routine requested by the function number.
6. Executes the routine in the AF4 area. (See Avoiding Excessive AF4 Execution Times.)
7. Writes the results at the result address in the data table.
8. Returns program execution to the next instruction in the user program after the AF4 function is completed. (See Avoiding Excessive AF4 Execution Times.)
9. Readies itself for the next AF4 operation.

AF4 Automatic Checks

To guard against improper program execution, automatic check routines are incorporated in the AF4. The processor uses these routines to prevent the following:

- Executing AF4 functions having invalid function addresses
- Spending so much time executing AF4 functions that the controller neglects its main program and I/O scans

Invalid Function Addresses

Valid AF4 function addresses include the I/O image table and the data table (except word 027). Specifically, valid addresses are from 010 to 026, from 030 to 077, and from 110 to the end of the data table. Result addresses must not reside in the input image table.

When a user programmed function has an invalid address, the response of the processor depends upon whether the keyswitch is in the RUN or RUN/PROGRAM position.

The response are:

In the RUN position, the processor stops running and the CRT displays PROCESSOR FAULT and CHANGE PROCESSOR TO PROGRAM MODE. The processor and memory LEDs illuminate. After you change processor operation to program mode the LEDs turn off and the CRT displays MODE SELECTION menu and PLC-2 RUN TIME ERROR, PRESS 11 TO CONTINUE. When you press 11 the CRT displays and intensifies the rung containing the illegal address and states ILLEGAL ADDRESS INTENSIFIED INSTRUCTION LINKED WITH CAUSE OF ERROR.

In the RUN/PROGRAM position, the processor stops running and the CRT displays MODE SELECTION menu and PLC-2 RUN TIME ERROR, PRESS 11 TO CONTINUE. When you press 11 the CRT displays and intensifies the rung containing the illegal address and states ILLEGAL ADDRESS INTENSIFIED INSTRUCTION LINKED WITH CAUSE OF ERROR.

Avoiding Excessive AF4 Execution Times

Table 3.B lists execution times for AF4 functions. To avoid excessive AF4 function execution times, an interlock system is designed into the AF4. This system automatically checks and does the following:

- Permits no AF4 function to run longer than 6ms without returning processor scan to the processor.
- During a program scan each true AF4 function rung which can be completed in a single scan will be completed as it is encountered. However, upon encountering a true AF4 function rung which requires multiple program scans to complete, all other true AF4 function rungs will be “locked out” until sufficient program scans complete the active AF4 function rung.
- Once started, it completes an AF4 function prior to starting the next AF4 function encountered in the user program which has a true rung condition.
- Limits the number of enabled AF4 functions in a program to 50. You may include more functions but you must ensure that no more than 50 are enabled at one time. This requirement only applies where you have programmed a function that requires more than one scan to complete.

This time listed in Table 3.B includes:

- Overhead for AF4 interlock system
- One run through the portion of the AF4 specified by the particular function

To obtain the time required from activation of the input that makes the rung containing the AF4 function true until the correct answer for the function is in the data table, you must add the following times to the values in Table 3.B:

- Input delay time (from specification for specific input)
- One program scan time and one I/O scan time multiplies by the number of scans specified in Table 3.B

Methods for determining these times are presented in Mini-PLC-2/15, Series B, Programmable Controller Programming and Operations Manual (publication 1772- 804).

Table 3.B
AF4 Execution Times [1]

Function
Log
Natural log
Reciprocal
Exponential
Powers

Function	[illegible]
Sine	
Cosine	
Square Root ($y^{00.5}$)	
BCD to Binary	
Binary to BCD	

Function	[illegible]
Addition	
Subtraction	
Multiplication	
Division	

[1]These times are calculated for a single AF4 function. Overhead for AF4 lock maintenance and multiple runs through the ladder program to complete some function is included.

Programming Specific Mathematical Functions

In this section we explain the following for each of the AF4 functions:

- What it is
- How to enter it in your program
- Its format in the data table

a. word arrangement

b. digit location

- Sample entry and display rungs. Although there are several techniques to enter this data, we use get instructions.
- Error messages. If an AF4 function has special error message responses to specific illegal programming procedures, we state these responses.

Status Bits

The most significant four bits of the most significant word of the result data area are reserved for status bits. These bits have the following meanings:

- Enable - bit 17
- Sign - bit 16
- Done - bit 15
- Error bit - bit 14

The enable bit is set at the start of an AF4 function and reset upon completion.

The sign bit, if set, indicates a negative value.

The done bit is reset at the start of an AF4 function and set upon completion.

The error bit is a general error flag that indicates overflow and invalid operand or result errors. Individual functions determine the actual state of this bit.

Throughout this manual, unused status bits are shown blank for the following reasons:

- Whether the content of an unused status bit is an input word is 0 or 1 is irrelevant as such bits are ignored in AF4 function execution.

- The AF4 reset unused status bits in result words. For simplicity these bits are left blank.

Accuracy

In the series A, revision A AF4, the typical error is ± 1 in the least significant digit (LSD). However, two functions have errors which exceed this limit. Function 32, $e^{\pm x}$, has error limits of +8 and -1 in the least significant digit for a range of x from 0.00 to -9.99.

Function 33, $y^{\pm x}$, has error limits of +6 and -1 in the least significant digit when x is negative.

AF4 Addition Function

An AF4 addition function operates on two 6-digit BCD numbers and presents the result in a third 6-digit BCD number.

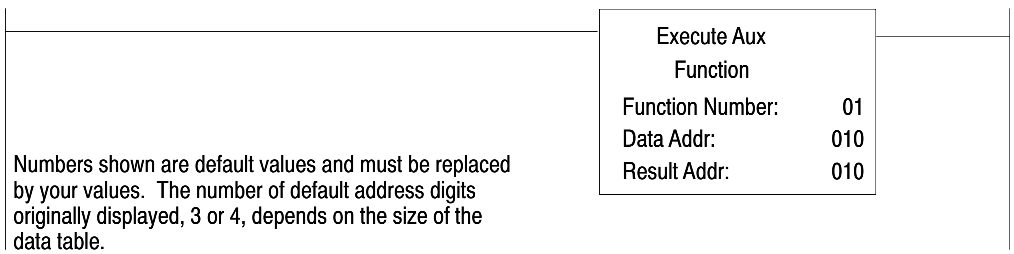
($\pm$xxx xxx.) + ($\pm$xxx xxx.) = $\pm$xxx xxx.

How to enter an AF4 Addition Function

To program an AF4 addition function, perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT

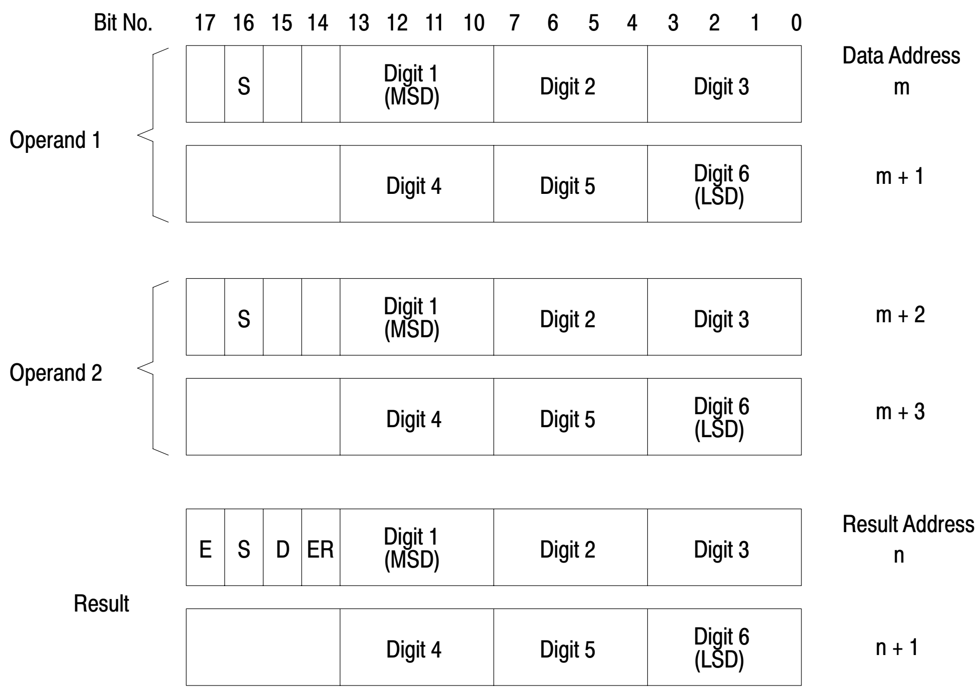
Figure 3.1
Execute Auxiliary Function Format



2. Enter 01, the function number for AF4 addition.

This entry identifies that the function entered is to perform an AF4 addition and that the processor use the data table format shown in Figure 3.2 when executed. Operands 1 and 2 represent the two 6-digit numbers we wish to add. The six digits of operand 1 are represented in BCD by the groups of bits labeled digit 1 through 6. Digit 1 and digit 6 are the most significant and the least significant digits respectively. This digit labeling system also applies to operand 2 and the result.

Figure 3.2
General AF4 Addition Function Word and Digit Format



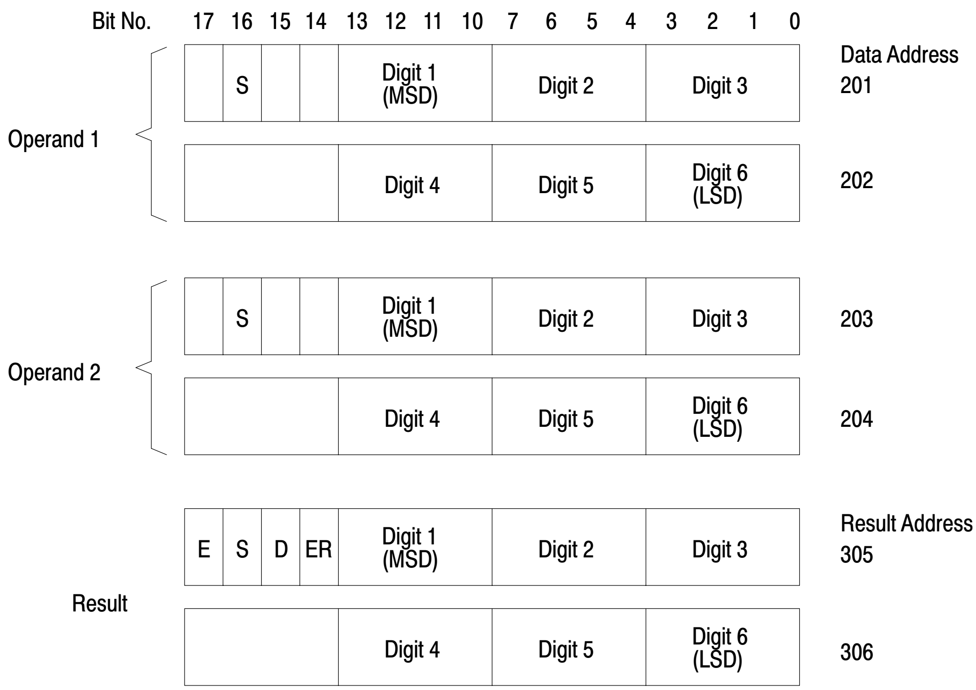
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Overflow)
MSD = Most Significant Digit
LSD = Least Significant Digit

11481

3. Enter a data address and a result address.

If we select a data address of 201 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.3. Be careful not to select data and result addresses so close together that the addresses of the operands following the data address overlap your result address. The data address eventually contains three digits of operand 1. The AF4 reserves the next three higher addresses for digits 4 through 6 of operand 1 and digits 1 through 6 of operand 2. The result address contains the most significant three digits of the result and the next higher address contains the least significant three digits.

Figure 3.3
AF4 Addition Function Formal After Address Entry



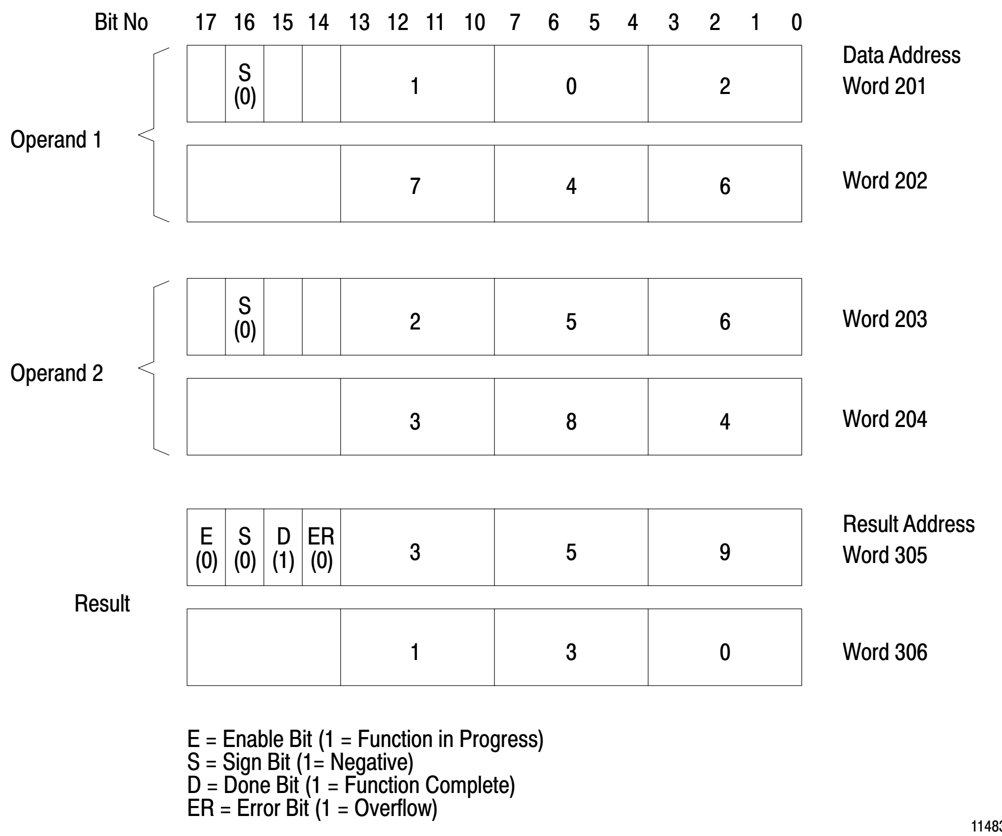
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Overflow)
MSD = Most Significant Digit
LSD = Least Significant Digit

11482

4. Enter values for operands 1 and 2.

You can enter these values from the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand 1 - 102746 and operand 2 - 256384 produces the result 359130 when the addition function executes. Figure 3.4 shows how the result is stored.

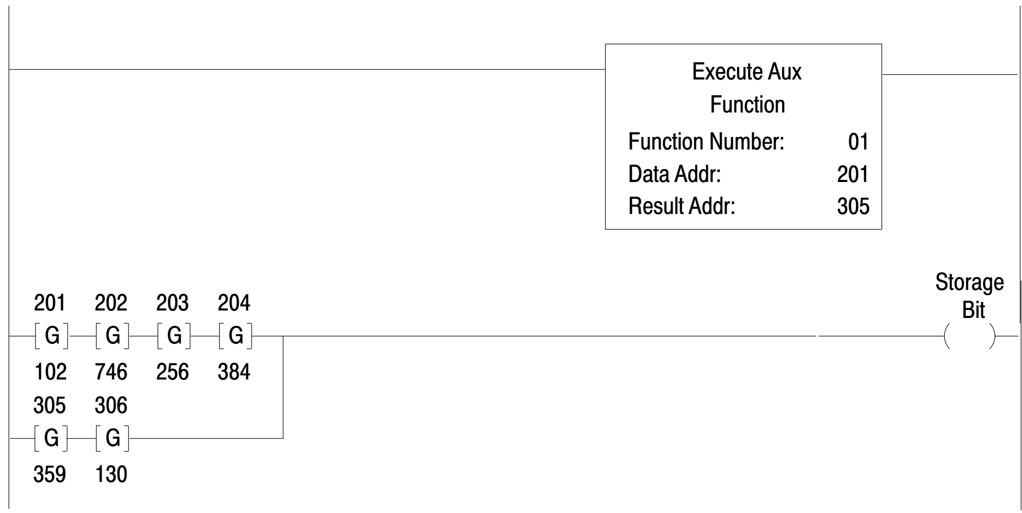
Figure 3.4
AF4 Addition Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.5 shows one method for inserting input values and displaying input values and results of AF4 addition computations. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests an AF4 addition. The second rung shows the two operands in its top branch and the resultant sum in its lower branch.

Figure 3.5
AF4 Addition Function Input and Result Display Rungs



Error Message

If the resultant sum has more than six integers, the error bit (bit 14) is set indicating overflow.

AF4 Subtraction Function

An AF4 subtraction function operates on two 6-digit BCD numbers and presents the result in a third 6-digit BCD number.

(±xxx xxx/ - ±xxx xxx.) = ±xxx xxx.

How to Enter an AF4 Subtraction Function

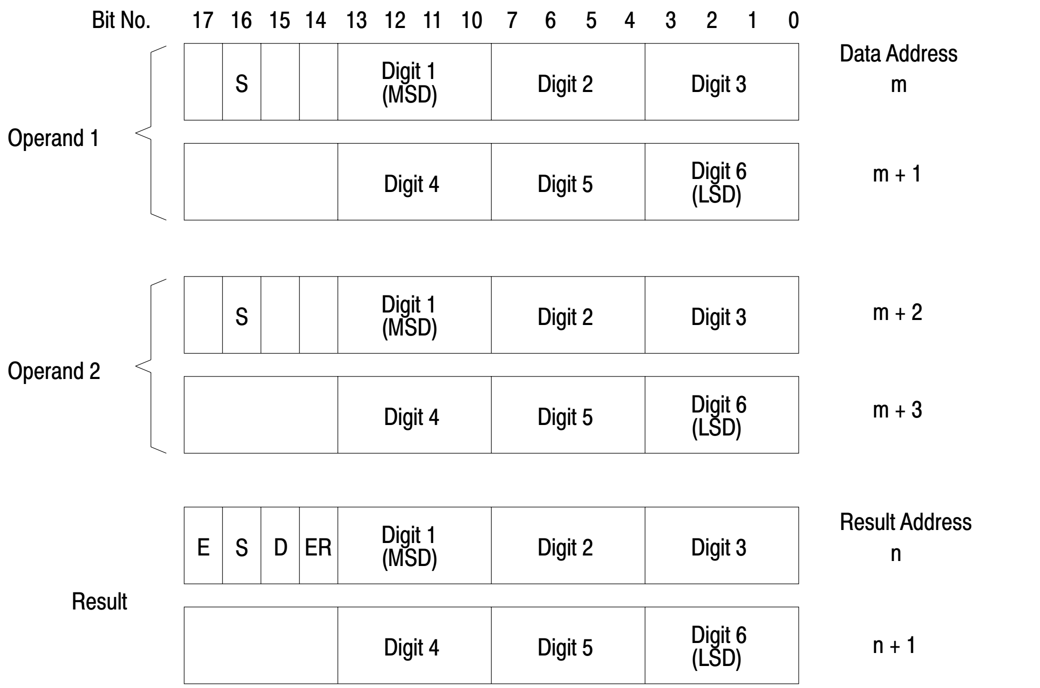
To program an AF4 subtraction function, perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 02, the function number for AF4 subtraction.

This entry identifies that the function entered is to perform an AF4 subtraction and that the processor use the data table format shown in Figure 3.6 when executed. Operands 1 and 2 represent the two 6-digit numbers whose difference you want to find. The six digits of operand 1 are represented in BCD by the group of bits labeled digit 1 through 6. Digit 1 and digit 6 are the most significant and the least significant digits respectively. This digit labeling system also applies to operand 2 and the result.

Figure 3.6
General AF4 Subtraction Function Word Digit Format



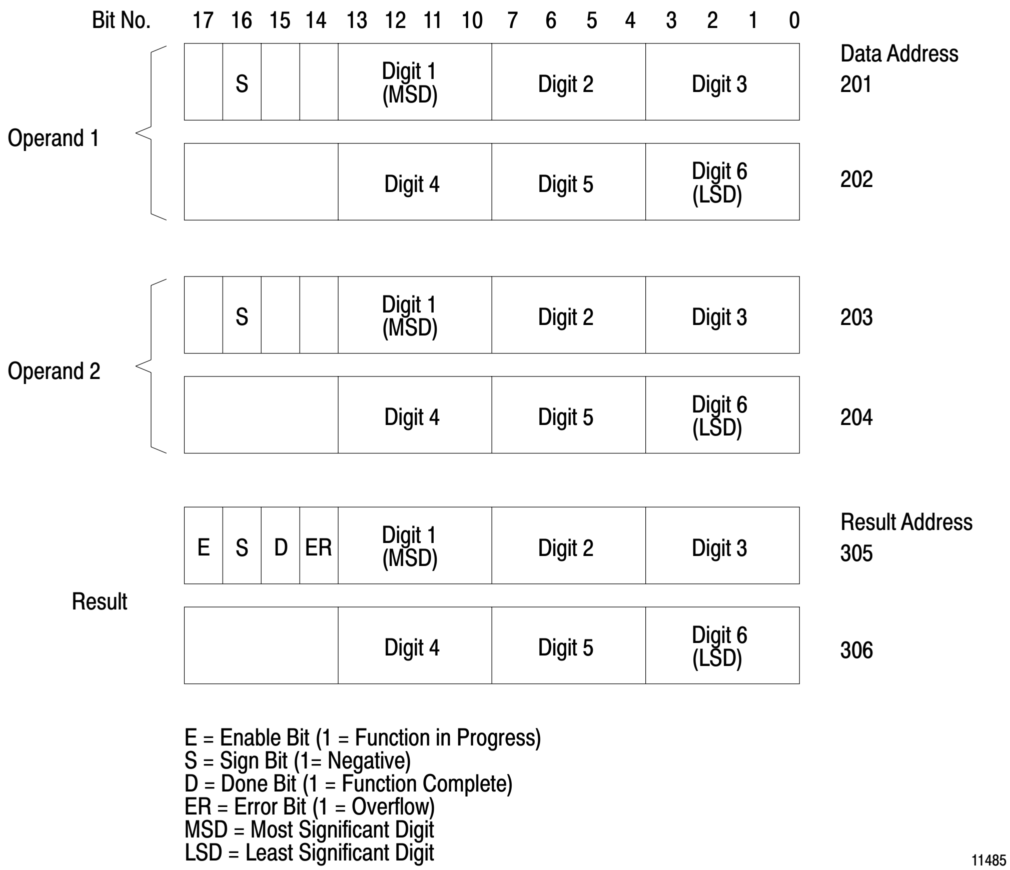
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Overflow)
MSD = Most Significant Digit
LSD = Least Significant Digit

11484

3. Enter a data address and a result address.

If we select a data address of 201 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.7. The data address eventually contains three digits of operand 2. The AF4 reserves the next three higher addresses for digits 4 through 6 of operand 1 and digits 1 through 6 of operand 2. The result address contains the most significant three digits of the result and the next higher address contains the least significant three digits.

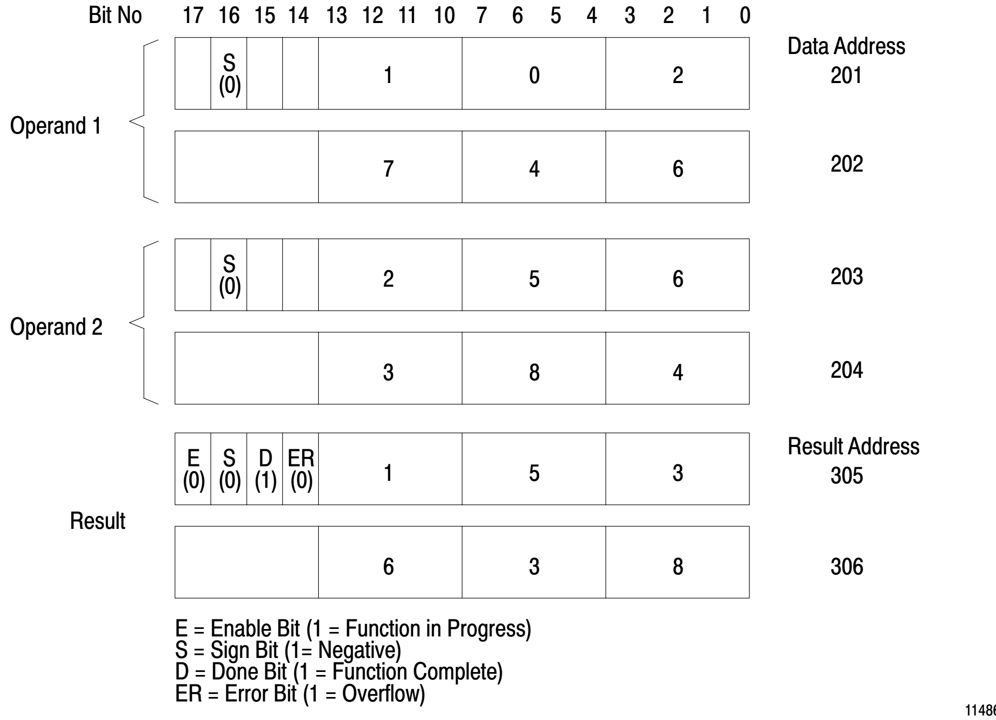
Figure 3.7
AF4 Subtraction Function Format After Address Entry



4. Enter values for operands 1 and 2.

You can enter these values form the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand 1 = 102746 and operand 2 256384 produces the result -153638 when the subtraction function executes. Figure 3.8 shows how the result is stored.

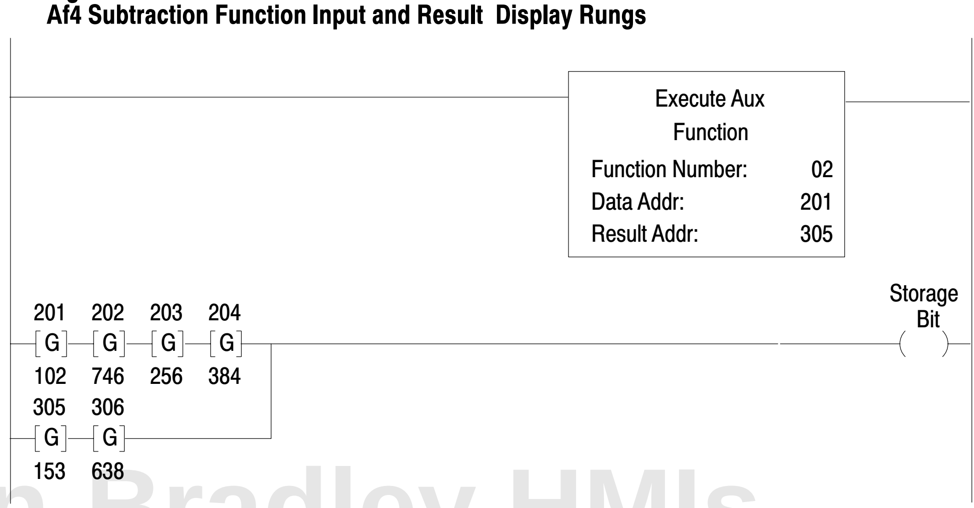
Figure 3.8
AF4 Subtraction Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.9 shows one method of inserting input values and displaying input values and results of AF4 subtraction computations. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests an AF4 subtraction. The second rung shows the two operands in its top branch and the resultant difference in its lower branch.

Figure 3.9
Af4 Subtraction Function Input and Result Display Rungs



Error Message

If the result has more than six integers, the error bit (bit 14) is set indicating overflow.

AF4 Multiplication Function

An AF4 multiplication function operates on two 6-digit BCD numbers and presents the results in a 12-digit BCD number.

($\pm$xxx xxx.) x ($\pm$xxx xxx.) = $\pm$xxx xxx xxx xxx.

How to Enter an AF4 Multiplication Function

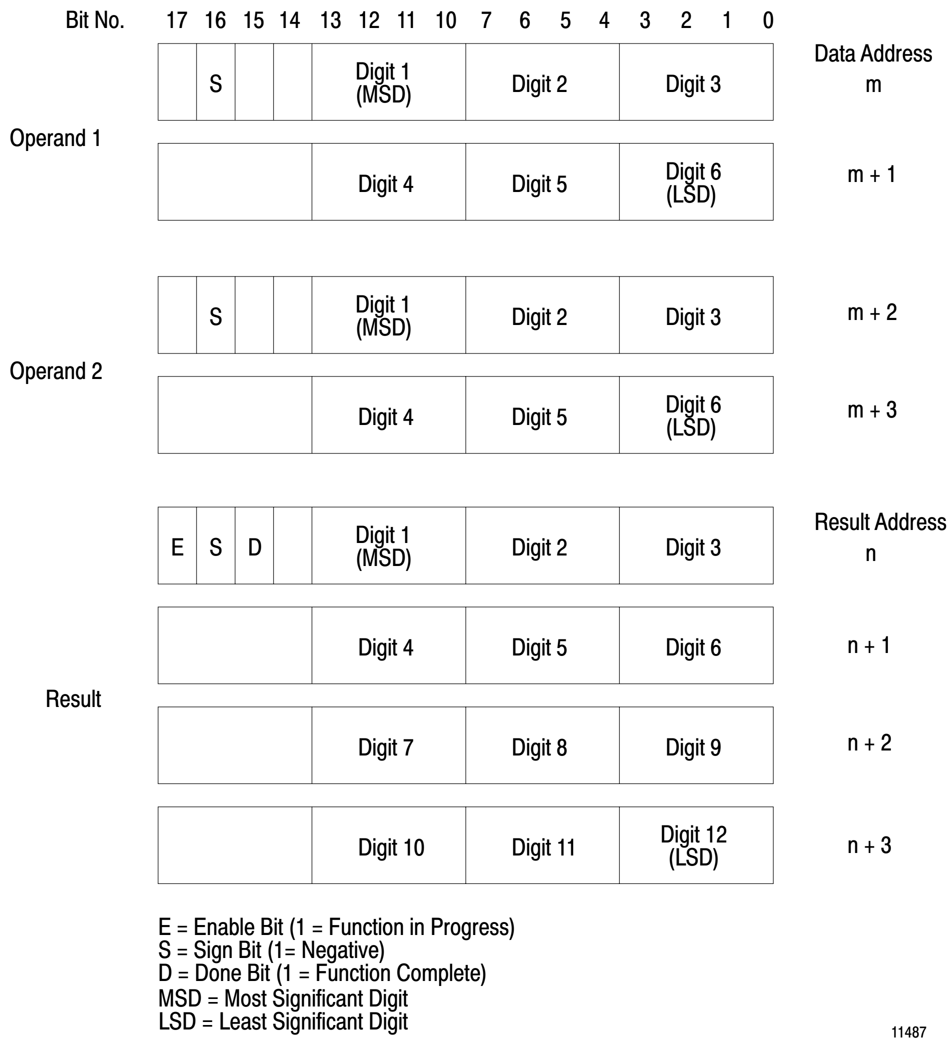
To program an AF4 multiplication function, perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 03, the function number for AF4 multiplication.

This entry identifies that the function entered is to perform an AF4 multiplication and that the processor use the data table format shown in Figure 3.10 when executed. Operands 1 and 2 represent two 6-digit numbers whose product you want to find. The six digits of operand 1 are represented in BCD by groups of bits labeled digit 1 through 6. Digit 1 and 6 are the most significant and least significant digits respectively. Operand 2 and the 12 digits of the result are labeled similarly.

Figure 3.10
General AF4 Multiplication Function Word and Digit Format



3. Enter a data address and a result address.

If we enter a data address of 201 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.11. The data address eventually contains the most significant three digits of operand 1. The AF4 reserves the next three higher addresses for the least significant three digits of operand 1 and the six digits of operand 2. The result address contains the most significant three digits of the result. The AF4 reserves the next three higher addresses for the remaining nine digits of the result.

Figure 3.11
AF4 Multiplication Function format After Address Entry

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	Data Address
Operand 1		S			Digit 1 (MSD)	Digit 2	Digit 3	201
					Digit 4	Digit 5	Digit 6 (LSD)	202
Operand 2		S			Digit 1 (MSD)	Digit 2	Digit 3	203
					Digit 4	Digit 5	Digit 6 (LSD)	204
								Result Address
Result	E	S	D		Digit 1 (MSD)	Digit 2	Digit 3	305
					Digit 4	Digit 5	Digit 6	306
					Digit 7	Digit 8	Digit 9	307
					Digit 10	Digit 11	Digit 12 (LSD)	310

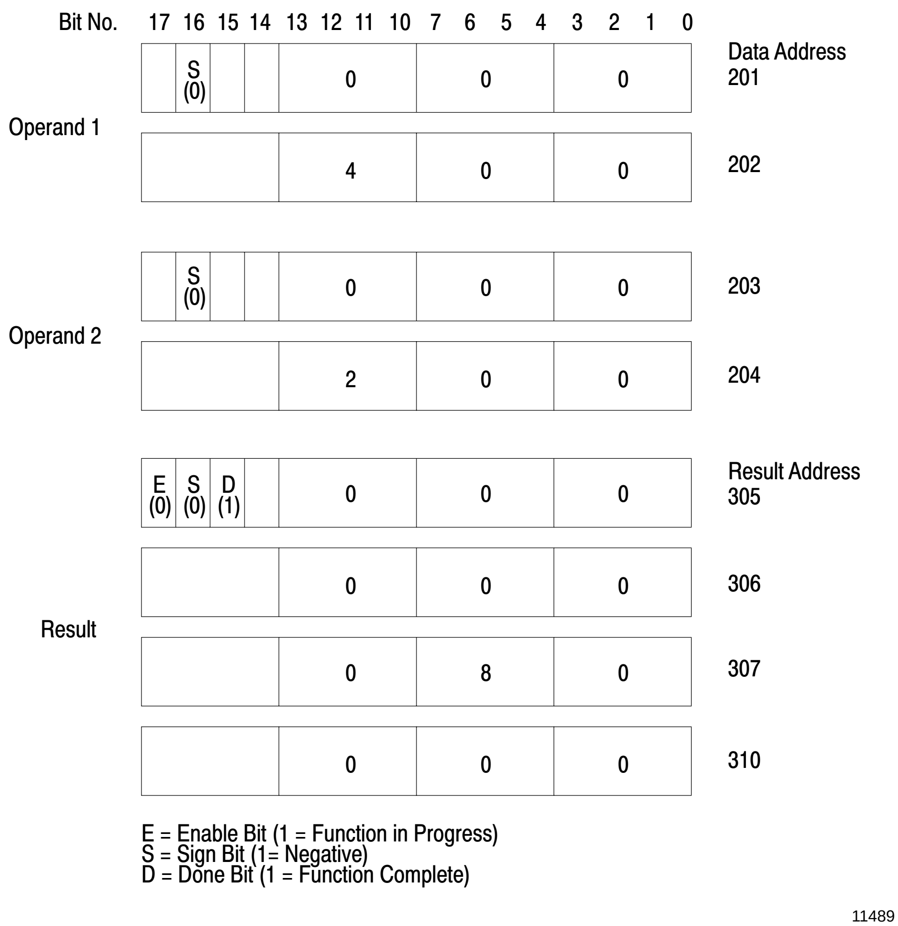
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
MSD = Most Significant Digit
LSD = Least Significant Digit

11488

4. Enter values for operands 1 and 2.

You can enter these values from the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand 1 - 000400 and operand 2 - 000200 produces the result 00000080000 (Figure 3.12).

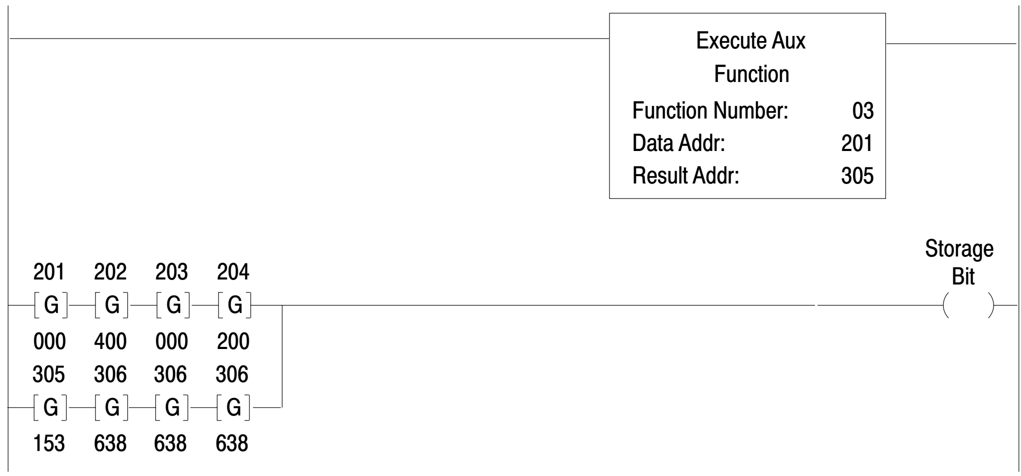
Figure 3.12
AF4 Multiplication Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.13 shows one method you can use to enter values for operands 1 and 2 and for displaying the results of an AF4 multiplication. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests an AF4 multiplication. The top branch of the second rung shows the two 6-digit operands while the lower branch shows the 12 digit product.

Figure 3.13
Af4 Multiplication Function Input and Result Display Rungs



AF4 Division Function

An AF4 division function operates on two 6-digit BCD numbers and presents the results in a 12-digit BCD number.

($\pm$xxx xxx.) : ($\pm$xxx xxx.) = $\pm$xxx xxx.xxx xxx

How to Enter an AF4 Division Function

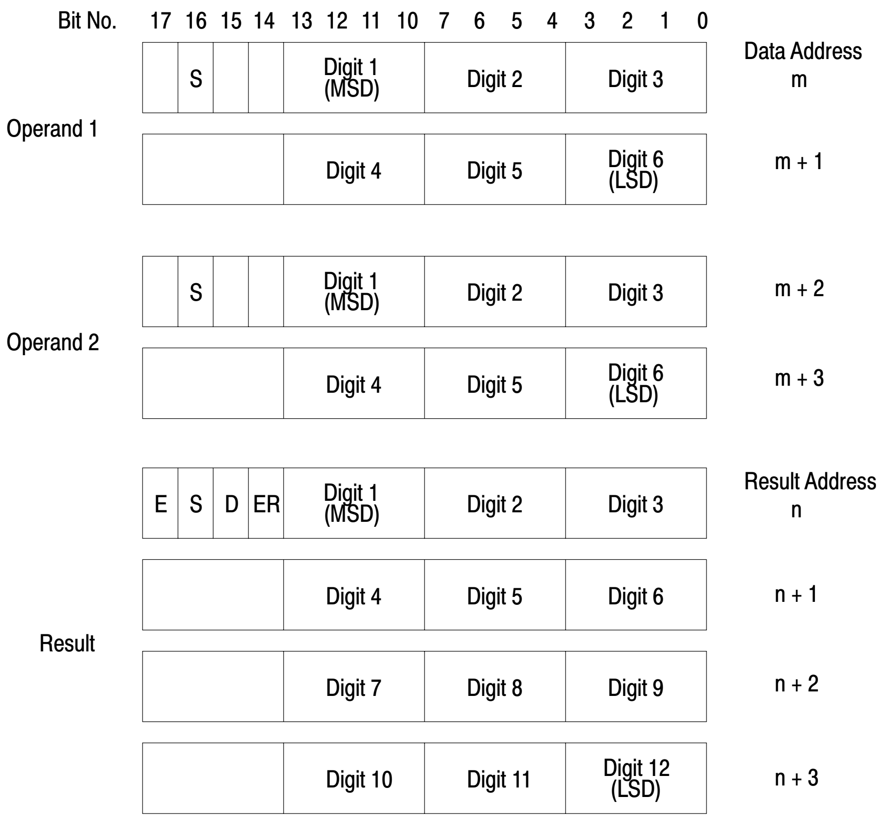
To program an AF4 division function, perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 04, the function number for AF4 division.

This entry identifies that the function entered is to perform an AF4 division and that the processor use the data table format shown in Figure 3.14 when executed. Operands 1 and 2 represent two 6-digit numbers whose quotient you wish to find. The six digits of operand 1 are represented in BCD by groups of bits labeled digit 1 through 6. Digit 1 and 6 are the most significant and least significant digits respectively. Operand 2 and the 12 digits of the result are labeled similarly.

Figure 3.14
General AF4 Division Function Word and Digit Format



E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
ER = Illegal Operand (Divide by Zero)
MSD = Most Significant Digit
LSD = Least Significant Digit

11490

3. Enter a data address and a result address.

If we enter a data address of 201 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.15. The data address eventually contains the most significant three digits of operand 1. The AF4 reserves the next three higher addresses for the least significant three digits of operand 1 and the six digits of operand 2. The result address contains the most significant three digits of the result. The AF4 reserves the next three higher addresses for the remaining nine digits of the result.

Figure 3.15
AF4 Division Function Format After Address Entry

	Bit No. 17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand 1		S			Digit 1 (MSD)	Digit 2	Digit 3	Data Address 201
					Digit 4	Digit 5	Digit 6 (LSD)	202
Operand 2		S			Digit 1 (MSD)	Digit 2	Digit 3	203
					Digit 4	Digit 5	Digit 6 (LSD)	204
Result	E	S	D	ER	Digit 1 (MSD)	Digit 2	Digit 3	Result Address 305
					Digit 4	Digit 5	Digit 6	306
					Digit 7	Digit 8	Digit 9	307
					Digit 10	Digit 11	Digit 12 (LSD)	310

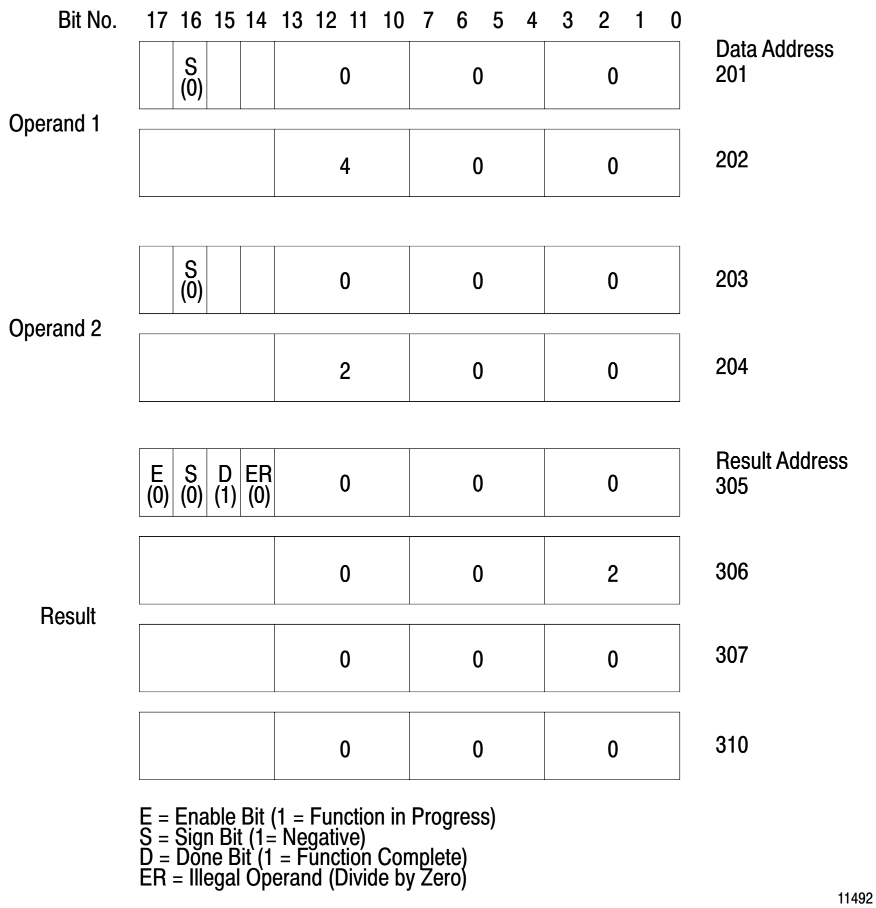
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
ER = Illegal Operand (Divide by Zero)
MSD = Most Significant Digit
LSD = Least Significant Digit

11491

4. Enter values for operands 1 and 2.

You can enter these numbers from the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand 1 = 000400 and operand 2 - 000200 produces the result 000002.000000 (Figure 3.16).

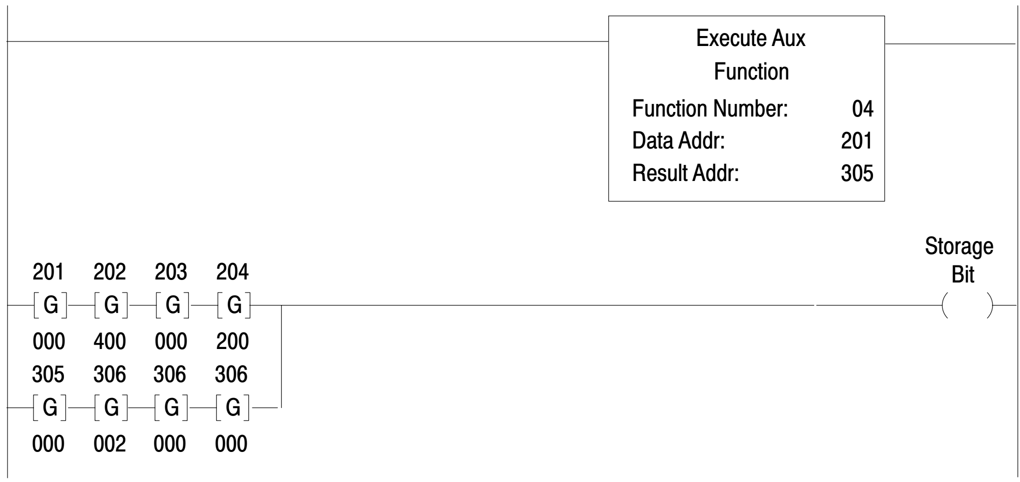
Figure 3.16
AF4 Division Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.17 shows one method you can use to enter values for operands 1 and 2 and for displaying the results of an AF4 division. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests an AF4 division function. The top branch of the second rung shows the two 6-digit operands while the lower branch shows the 12 digit quotient.

Figure 3.17
AF4 Division Function Input and Result Display Rungs



Error Message

If you divide by zero, the error bit (bit 14) is set and the result reads zero.

AF4 BCD to Binary Conversion Function

The AF4 BCD (binary coded decimal) to binary conversion function converts a BCD number (from 0 to 4095) into a 12-bit binary number.

How to Enter an AF4 BCD to Binary Conversion Function

To program an AF4 BCD to binary conversion function, perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the industrial terminal keyboard. Figure 3.1 appears on the CRT.

2. Enter 13, the function number for AF4 BCD to binary conversion.

This entry identifies that the function entered is to perform an AF4 BCD to binary conversion and that the processor use the data table format shown in Figure 3.18 when executed.

Figure 3.18
General AF4 BCD to Binary Conversion Function Word and Digit Format

Bit No.	17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
Operand		S			Digit 1 (MSD) (Always = 0)				Digit 2 (Always = 0)				Digit 3 (Must be 3 4)				Data Address m
					Digit 4				Digit 5				Digit 6 (LSD)				m + 1
Result	E	S	D	ER													Result Address n

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = BCD Number > 4095 Entered)
MSD = Most Significant Digit
LSD = Least Significant Digit

11493

3. Enter a data address and a result address.

If we choose a data address of 200 and a result address of 300, the data table format is as shown in Figure 3.19. The most significant three digits of the operand (the BCD number we want to convert to binary) reside in the data address word 200 and the least significant three digits reside in the next higher address, 201. The first two digits are always zero and the third digit must not exceed four. The number, converted to binary format, is stored in bits 0 through 13 in the result address, word 300.

Figure 3.19
AF4 BCD to Binary Conversion Function Format After Address Only

Bit No.	17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0	
Operand		S			Digit 1 (MSD) (Always = 0)				Digit 2 (Always = 0)				Digit 3 (Must be 3 4)				Data Address 200
					Digit 4				Digit 5				Digit 6 (LSD)				201
Result	E	S	D	ER													Result Address 300

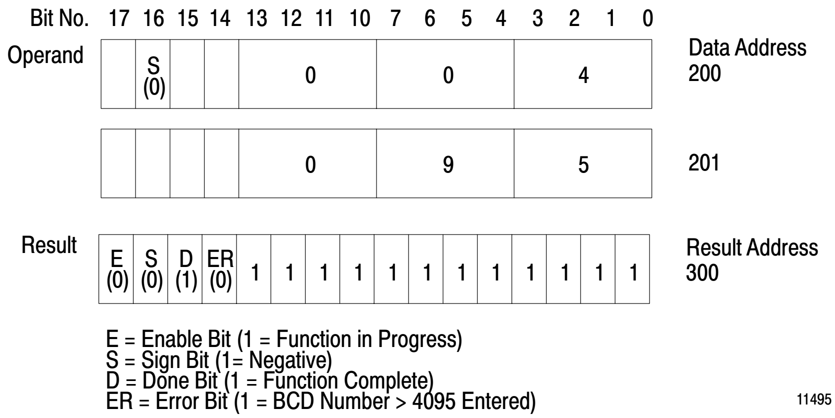
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1= Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = BCD Number > 4095 Entered)
MSD = Most Significant Digit
LSD = Least Significant Digit

11494

4. Enter the operand.

You can enter the operand from the keyboard of your industrial terminal or through ladder diagram functions. If we choose to enter 4095, the largest BCD number that we can convert to a 12 bit binary number, we obtain the data table configuration shown in Figure 3.20.

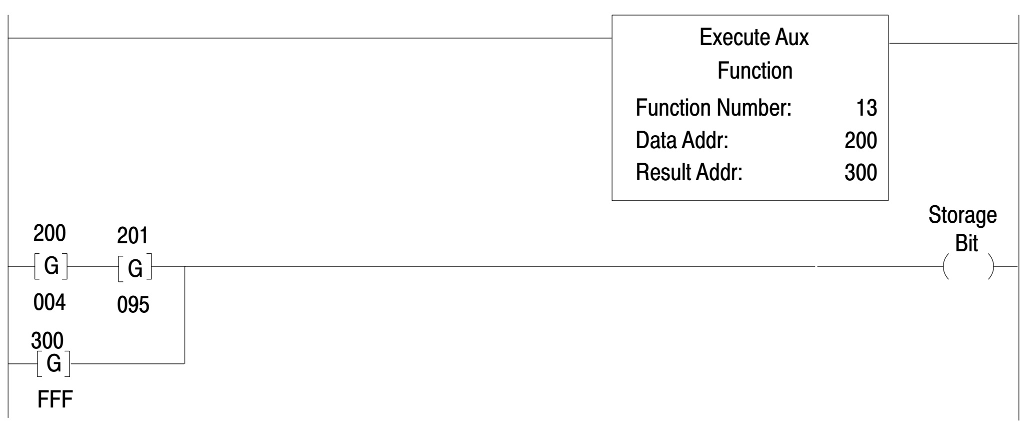
Figure 3.20
Af4 BCD to Binary Conversion Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.21 shows one method for inserting input values and displaying inputs and results of an AF4 BCD to binary conversion. Although there are other methods for accomplishing this, we chose get instructions. The first rung requests an AF4 BCD to binary conversion. The top branch of the second rung shows the BCD number we want to convert (004095) in words 200 and 201. The bottom branch shows in the hexadecimal notation FFF (bits 0 through 13 in word 300 have the states shown in Figure 3.20).

Figure 3.21
AF4 BCD to Binary Conversion Function Input and Display Rungs



Error Message

If you enter a BCD number larger than 4095, the error bit (bit 14) is set and the result reads zero.

AF4 Binary to BCD Conversion Function

The AF4 binary to BCD conversion function converts a 12-bit binary number to a BCD number (from 0 to 4095).

How to Enter an AF4 Binary to BCD Conversion Function

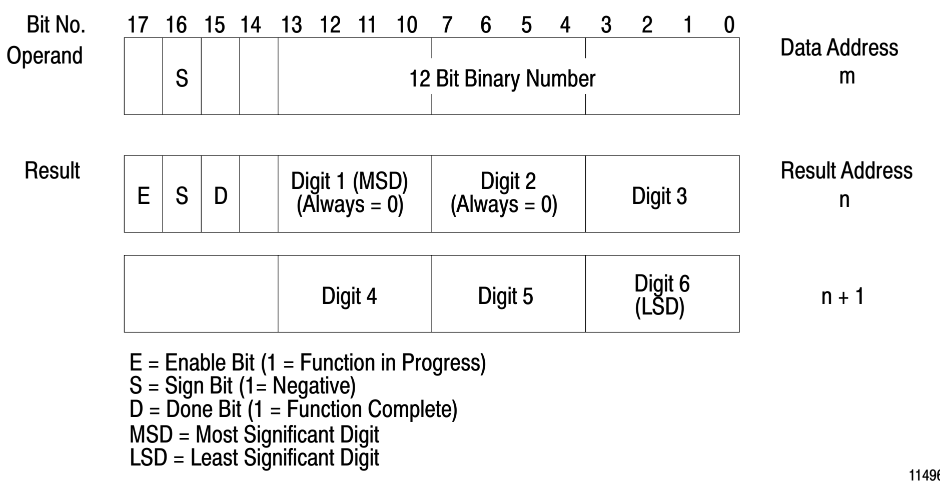
To program an AF4 binary to BCD conversion function, perform the following steps:

1. Press [SHIFT][EAF]or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 14, the function number for the AF4 binary to BCD conversion.

This entry identifies that the function entered is to perform an AF4 binary to BCD conversion and that the processor use the data table format shown in Figure 3.22 when executed.

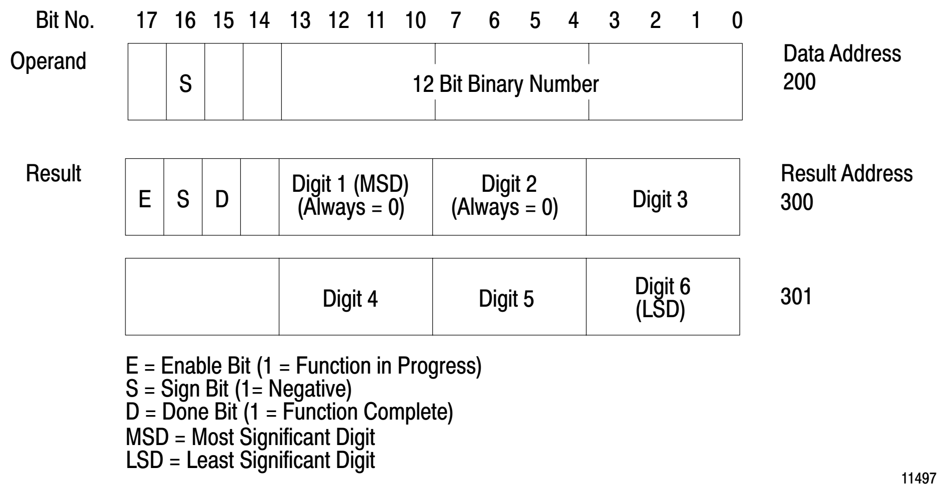
Figure 3.22
General AF4 Binary to BCD Conversion Function Word and Digit Format



3. Enter a data address and a result address.

If we choose a data address of 200 and a result address of 300, the data table format is as shown in Figure 3.23. Bits 0 through 13 or word 200 are reserved for the operand (the 12-bit binary number we want to convert to BDD). The result address, 300, contains the most significant three digits of the resulting BCD number and the least significant three digits reside in the next higher address, 301. The first two digits of the BCD number are always zero and the third digit can not exceed four.

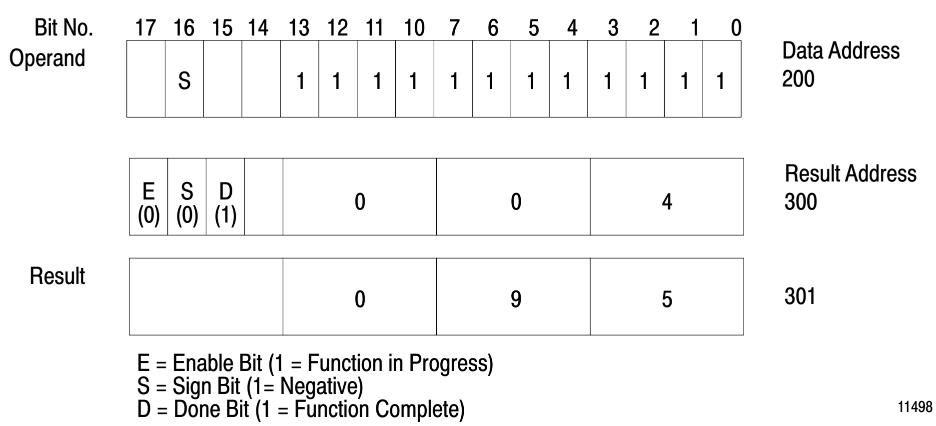
Figure 3.23
AF4 Binary to BCD Conversion Function Format After Address Entry



4. Enter the operand.

You can enter the operand from the keyboard of your industrial terminal or through ladder diagram functions. If we choose to set bits 0 through 13 in word 200, that is, insert the largest possible binary number in 12 bits, we obtain 4095 for the corresponding BCD number (Figure 3.24). The ones in bits 0 through 13 of word 200 indicate that each bit is set.

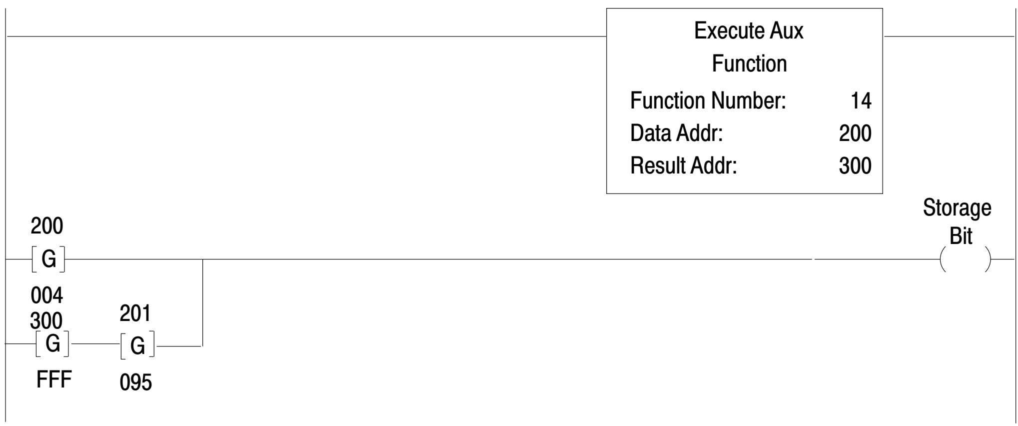
Figure 3.24
AF4 Binary to BCD Conversion Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.25 shows one method for inserting input values and displaying inputs and results of an AF4 binary to BCD conversion function. Although there are other methods for accomplishing this, we chose get instructions. The first rung requests an AF4 binary to BCD conversion function. The top branch of the second rung shows the binary number (in the hexadecimal notation FFF) that we want converted to BCD. In this example, the binary number is the largest possible, with bits 0 through 13 of word 200 set as shown in figure 3.24. The lower branch shows the resulting BCD number, 004095, in words 300 and 301.

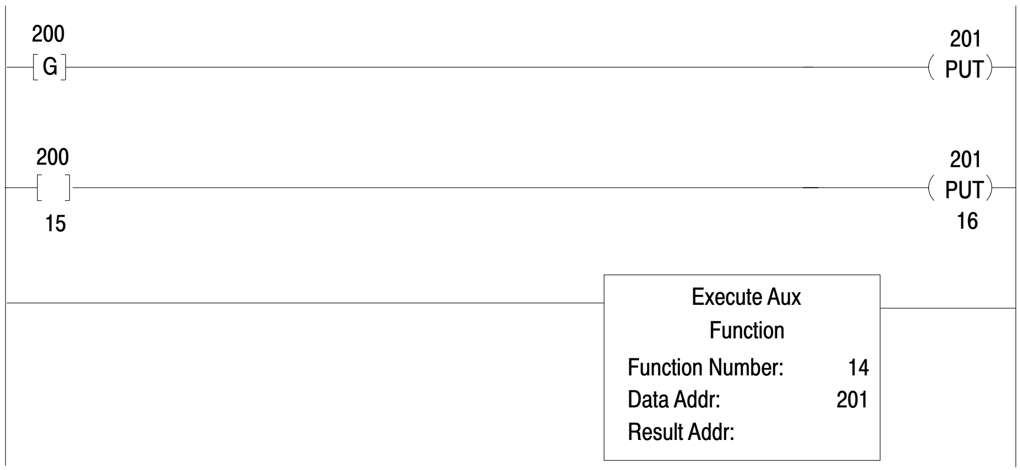
Figure 3.25
AF4 Binary to BCD Conversion Function Input and Result Display Rungs



Sign Bits

If you encounter any binary data where the sign bit is not in bit 16, you must move the sign bit into bit 16 of an auxiliary data table word prior to doing a binary to BCD conversion. If, for example, the sign bit of your module is bit 15 in word 200, the rungs in Figure 3.26 permit you to make a binary to BCD conversion. The first rung puts word 200 data into word 201. Rung two sets bit 16 in word 201 if bit 15 in word 200 is set. The AF4 binary to BCD conversion function in rung three then uses word 201 as its data address.

Figure 3.26
Transfer of Sign Bit



AF4 Log to Base 10 Function

The AF4 log to the base 10 function finds the log of a 3-digit BCD integer. The result is a 6-digit BCD number with an implied decimal point after the most significant digit.

log (xxx.) - x.xx xxx

How to Enter an AF4 Log to Base 10 Function

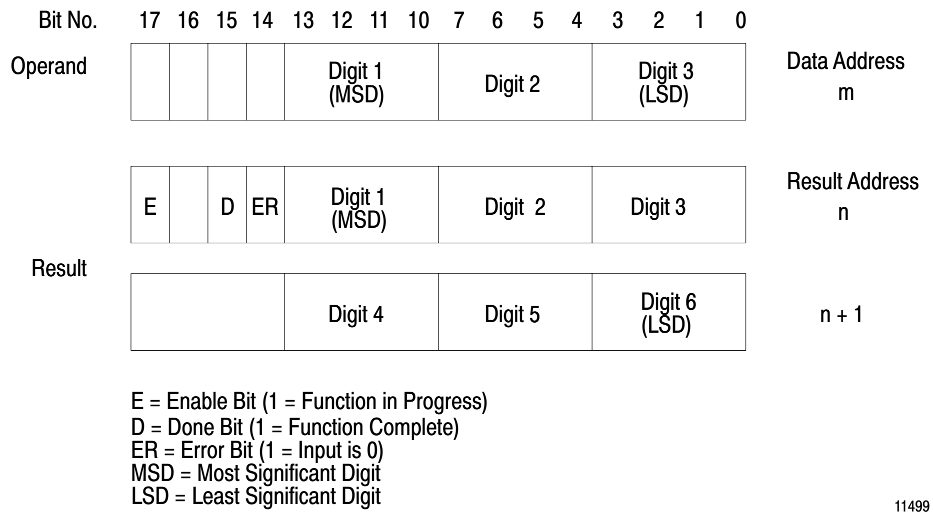
To program an AF4 log to base 10 function perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears in the CRT.

2. Enter 30, the function number for an AF4 log to base 10 function.

This entry identifies that the function entered is to perform an AF4 log to base 10 calculation and that the processor use the data table format shown in Figure 3.27 when executed. The three digits of the number whose log you want are represented in BCD by the digits labeled 1 through 3 in the operand. The 6-digit result is represented by digits labeled 1 through 6. The most significant digit (MSD) and least significant digit (LSD) are labeled.

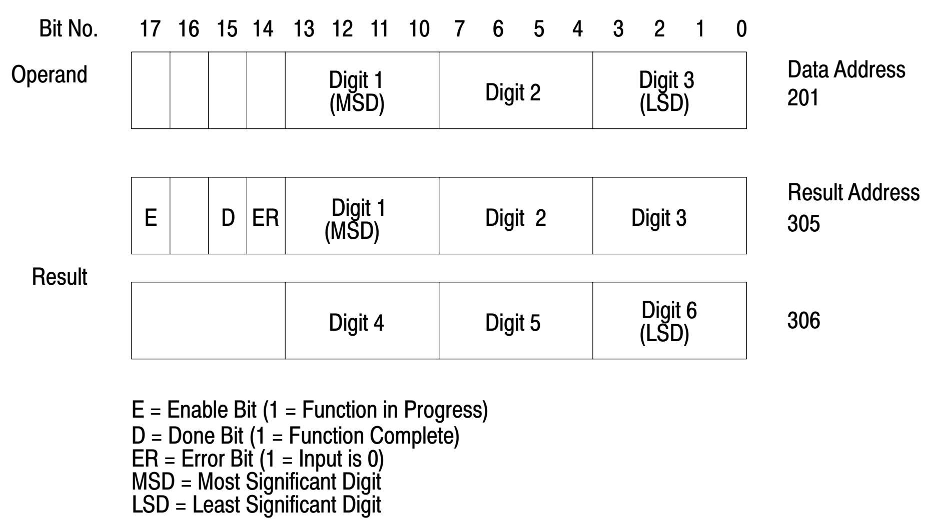
Figure 3.27
General AF4 Log to Base 10 Function Word and Digit Format



3. Enter a data address and a result address.

If we select a data address of 201 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.28. The data address is reserved for the three digits of the number whose log you want. The result address, 305, is reserved for the first three digits of the resultant log; the next higher address, 306, is reserved for the last three digits. The implied decimal point in the result is after the MSD.

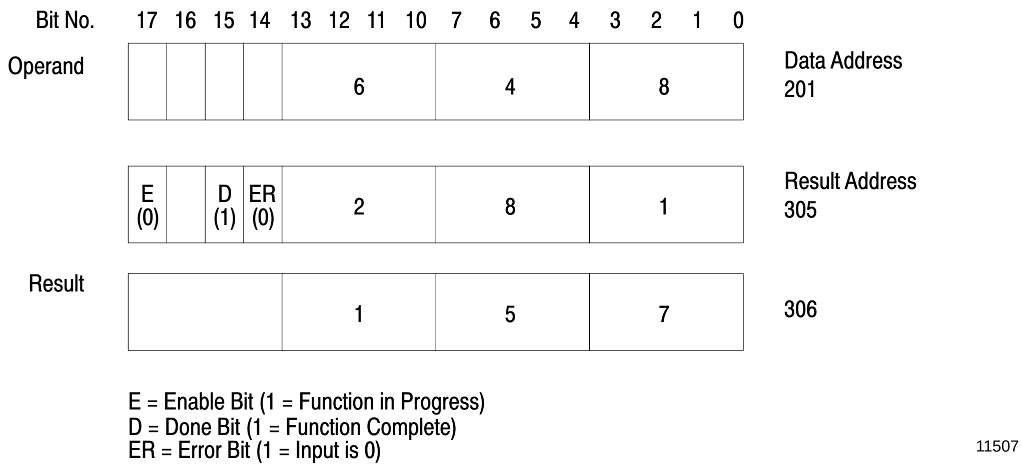
Figure 3.28
AF4 Log to Base 10 Function Format After Address Entry



4. Enter the operand.

You can enter the operand from the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand - 648 produces the result 2.81157 when the log function executes. Figure 3.29 shows how the result is stored.

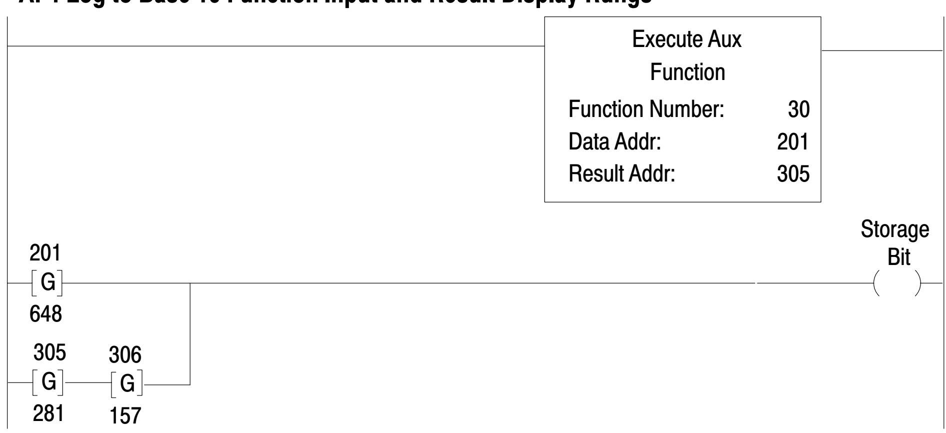
Figure 3.29
AF4 Log to Base 10 Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.30 shows one method for inserting the operand and displaying the input value and result of an AF4 log to base 10 function. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests an AF4 log to base 10 function. The second rung shows the operand 648 in word 201 in the upper branch and the desired log 2.81157 in words 305 and 306 in the lower branch.

Figure 3.30
AF4 Log to Base 10 Function Input and Result Display Rungs



Error Messages

If you try to find the log of zero, the error bit is set and the result is zero.

AF4 Natural Log Functions

The AF4 natural log function finds the natural log of a 3-digit BCD integer to the base e. The result is a 6-digit BCD value with an implied decimal point after the most significant digit.

In (xxx.) - x.xx xxx

How to Enter an AF4 Natural Log Function

To program an AF4 natural log function, perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 31, the function number for the AF4 natural log function.

This entry identifies that the function entered is to perform an AF4 natural log calculation and that the processor use the data table format shown in Figure 3.31 when executed. The three digits of the operand (the number whose natural log you want) and represented in BCD by the groups of bits labeled digit 1 through 3. The six digits of the result are labeled digit 1 through 6. A decimal point is implied after the MSD.

Figure 3.31
General AF4 Natural Log Function Word and Digit Format

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand					Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address m
Result	E		D	ER	Digit 1 (MSD)	Digit 2	Digit 3	Result Address n
					Digit 4	Digit 5	Digit 6 (LSD)	n + 1

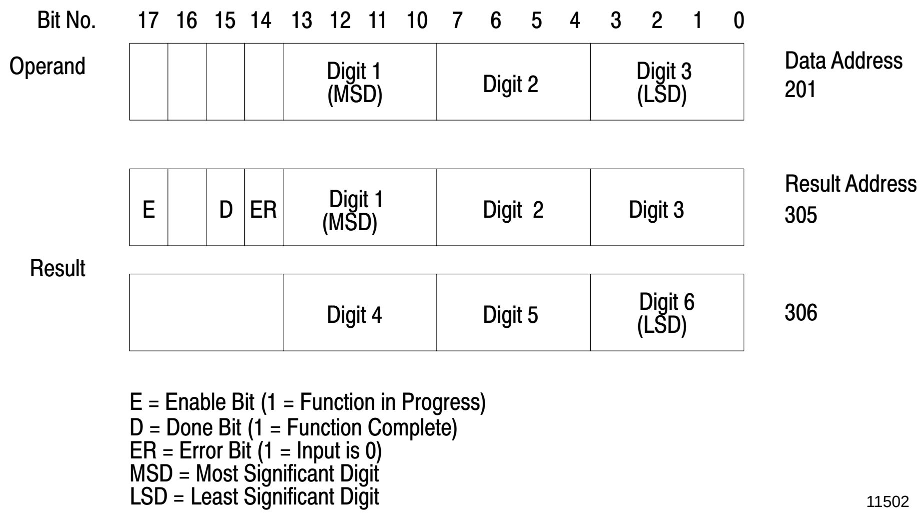
E = Enable Bit (1 = Function in Progress)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Input is 0)
MSD = Most Significant Digit
LSD = Least Significant Digit

11501

3. Enter a data address and a result address.

If we enter a data address of 201 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.32. The data address eventually contains the operand. The result address (word 305) contains the first three digits of the result and word 306 contains the last three digits.

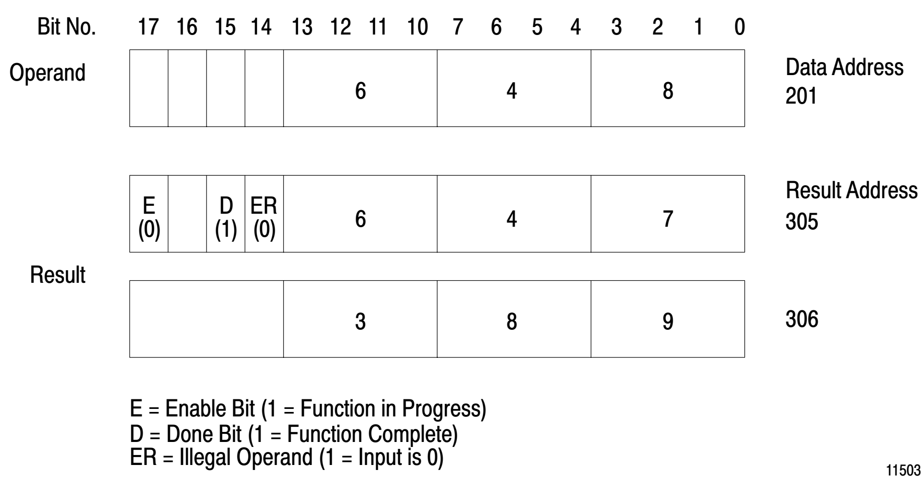
Figure 3.32
AF4 Natural Log Function Format After Address Entry



4. Enter the number for the operand.

You can enter this number from the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand = 648 produces the result 6.47389 when the natural log function executes. Figure 3.33 shows how the result is stored.

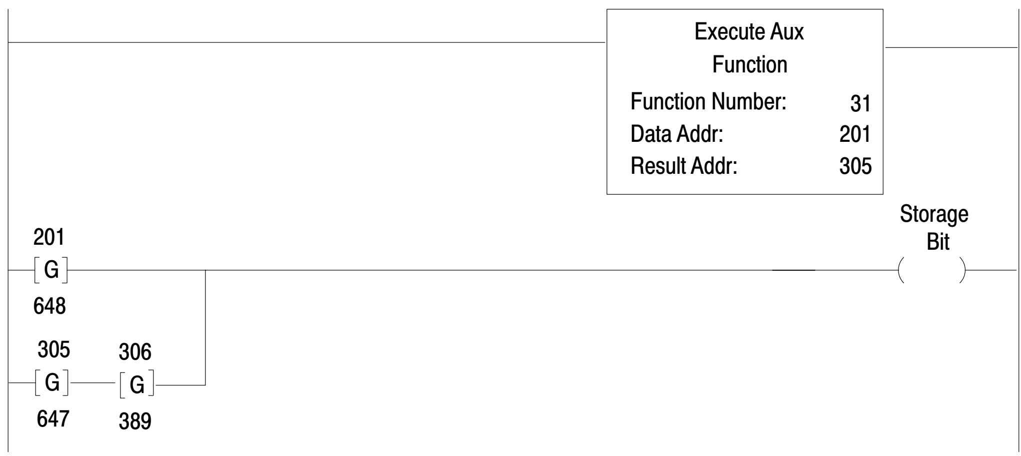
Figure 3.33
AF4 Natural Log Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.34 shows one method for inserting the operand and displaying the input value and result of an AF4 natural log function. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests an AF4 natural log function. The second rung shows the operand 648 in word 201 in the upper branch and the desired natural log 6.47389 in words 305 and 306 in the lower branch.

Figure 3.34
AF4 Natural Log Function Input and Result Display Rungs



Error Messages

If you try to find the natural log of zero, the error bit is set and the result is zero.

AF4 Exponential Function

The AF4 exponential function finds the value of the exponential function ex. The result is in terms of a base number r and a power of 10, s, by which the base number is multiplied to obtain the exponential function value. The equation is:

$e^{\pm x}=r(10)^s$

where:

x= $\pm$X.XX

r = resultant base number = X.XX

s = the exponent of 10 = $\pm$X.

How to Enter an AF4 Exponential Function

To program an AF4 exponential perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 32, the function number for an AF4 exponential function.

This entry identifies that the function entered is to perform an AF4 exponential calculation and that the processor use the data table format shown in Figure 3.35 when executed.

Figure 3.35
General AF4 Exponential Function Word and Digit Format

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address m
Result Base r	E		D		Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Result Address n
s (Power of 10)		S			Digit 1 (MSD) (Always = 0)	Digit 2 (Always = 0)	Digit 3 (LSD)	n + 1

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
MSD = Most Significant Digit
LSD = Least Significant Digit

11504

3. Enter a data address and a result address.

If we choose a data address of 200 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.36. The three digits of the word 200 are reserved for the operand (the power to which e is being raised). The result address is reserved for the three digits of 4, the base number of the answer with an implied decimal after the MSD. The next higher address, word 306, is reserved for s, the power of 10. The implied decimal point of exponent s is after the LSD; the MSD and digit 2 are always zero. The base number r is accurate to $\pm$.01.

Figure 3.36
AF4 Exponential Function Format After Address Entry

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address 200
Result Base r	E		D		Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Result Address 305
s (Power of 10)		S			Digit 1 (MSD) (Always = 0)	Digit 2 (Always = 0)	Digit 3 (LSD)	306

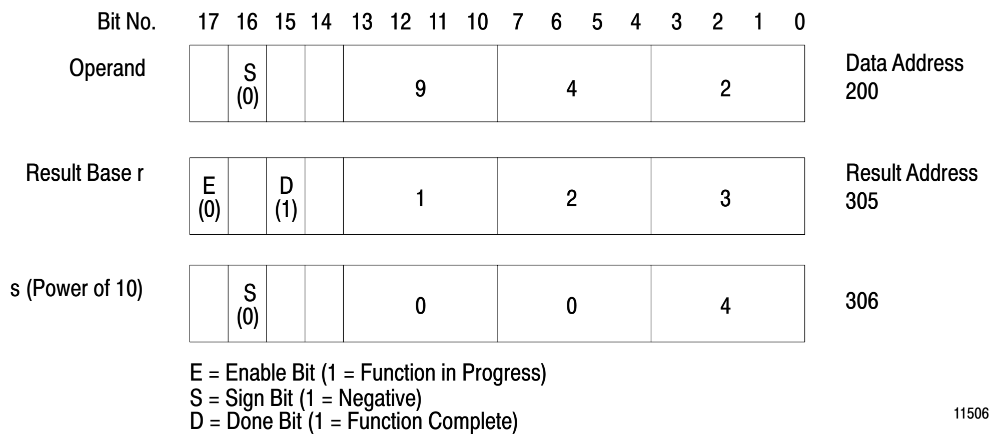
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
MSD = Most Significant Digit
LSD = Least Significant Digit

11505

4. Enter the operand.

You can enter the operand from the keyboard of your industrial terminal or through ladder diagram functions. Entry of an operand (exponent) of e) of 9.42 yields an exponential function value of $1.23(10)^{004}$. The base r resides in word 305 and the exponent of ten resides in word 306 as shown in Figure 3.37.

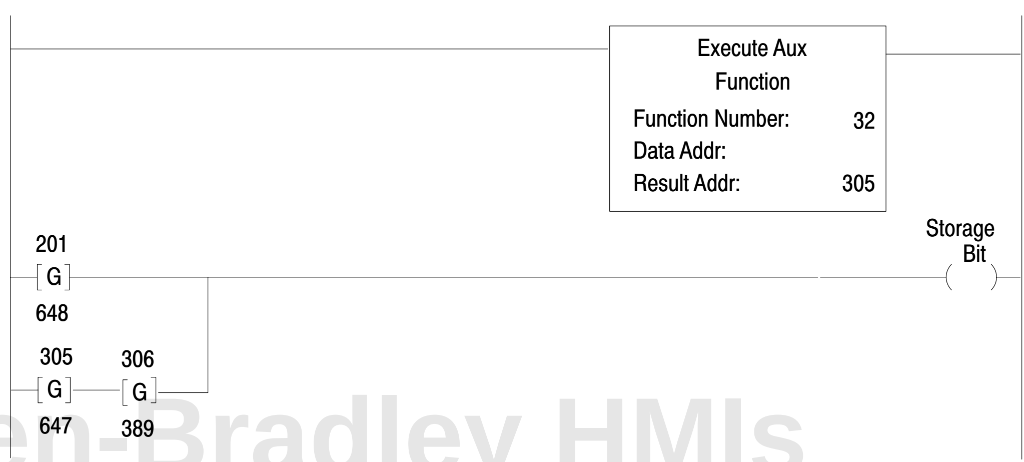
Figure 3.37
AF4 Exponential Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.38 shows one method for inserting input values and displaying input values and results of an AF4 exponential function. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests execution of an AF4 exponential function. The second rung contains 9.42, the exponent of e in word 200 with an implied decimal point after the first digit. It also shows the result, $(1.23)(10)^{004}$, in the form of 123 in word 305 and 004 in word 206. The decimal points are implied.

Figure 3.38
AF4 Exponential Function Input and Result Display Rungs



AF4 Power Function

The AF4 power function evaluates y±x and gives the result in terms of a base number r and a power of 10, s, by which you multiply this base number to obtain the power function value. The equation is:

$y \pm x = r(10)^{\pm s}$

where:

y = input base = XXX.

x = input exponent = XX.X

r = result base = X.XX

s = resultant exponent = ±XX. (The first digit is always zero)

A request for zero to the zero power will result in plus one.

How to Enter an AF4 Power Function

To program an AF4 power function perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 33, the function number for an AF4 power function.

This entry identifies that the function entered is to perform an AF4 power function calculation and that the processor use the data table format shown in Figure 3.39 when executed. The data address is reserved for the three digits of the base number y. Digits 1 and 3 are the most significant digit (MSD) and least significant digit (LSD) respectively. The implied decimal point is after the LSD. The three digits in the next higher address are reserved for the exponent, x, with an implied decimal point after digit 2. The three digits of the result address are reserved for the result base, r, with the decimal point after the MSD. The next higher address is reserved for the resultant exponent s. Digit one of the exponent s is always zero; the implied decimal point is after digit 3.

Figure 3.39
General AF4 Power Function Word and Digit Format

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Base y		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address m
Exponent x		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	m + 1
Result Base, r	E		D	ER	Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Result Address n
s (Power of 10)		S			Digit 1 (MSD) (Always = 0)	Digit 2	Digit 3 (LSD)	n + 1

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Overflow when $y^x > 9.99(10)^{99}$)
MSD = Most Significant Digit
LSD = Least Significant Digit

11508

3. Enter a data address and a result address.

If we enter a data address of 200 and a result address of 300, the AF4 establishes the data table format shown in Figure 3.40. Word 200 is reserved for the base y and word 201 is reserved for the exponent x. The result address, word 300, is reserved for the result base r; word 301 contains the resultant exponent s.

Figure 3.40
AF4 Power Function Format After Address Entry

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Base y		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address 200
Exponent x		S				Digit 1 (MSD)	Digit 2 (LSD)	201
Result Base, r	E		D	ER	Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Result Address 300
s (Power of 10)		S			Digit 1 (MSD) (Always = 0)	Digit 2	Digit 3 (LSD)	301

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Overflow when $y^x > 9.99(10)^{99}$)
MSD = Most Significant Digit
LSD = Least Significant Digit

11509

4. You can enter base y and exponent x values from the keyboard of the industrial terminal or through ladder diagram functions. Entry of y - 124 in word 200 and 2 - 02.0 in word 201 produces the result 15376 when the power function executes. Figure 3.41 shows how the result is stored as $1.53(10)^4$. The result is truncated.

Figure 3.41
AF4 Power Function Format After Execution

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Base y		S (0)			1	2	4	Data Address 200
Exponent x		S (0)			0	2	0	201
Result Base, r	E (0)		D (1)	ER (0)	1	5	3	Result Address 300
s (Power of 10)		S (0)			0	0	4	301

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Overflow when y^x > $9.99(10)^{099.}$)

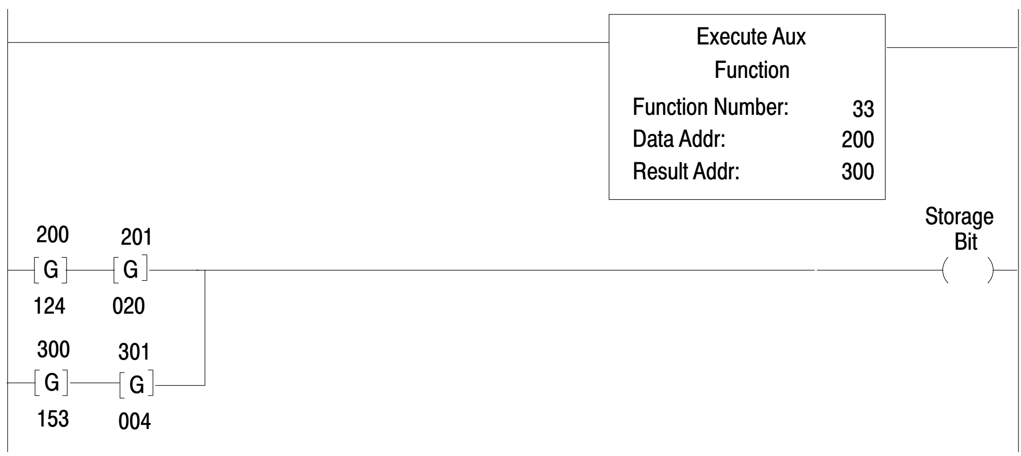
11510

Entry and Display of Input and Result Values

Figure 3.42 shows one method for inserting the input values and displaying input values and result of an AF4 power function. Although there are several techniques for accomplishing this, we chose get instructions.

The first rung requests the AF4 to evaluate a power function. The top branch of the second rung contains the input base, 124, in word 200 and the input exponent 02.0 in word 201. The lower branch of rung 2 contains the result, $1.53(10^4)$ in the form of result base (153) in word 300 and result exponent (004) in word 301. The implied decimal points in the result base and result exponent are after digits 1 and 3 respectively.

Figure 3.42
AF4 Power Function Input and Result Rungs



Error Message

If you input a negative number for the input base y, the absolute value of y is used and the error bit is set.

If yx $\geq 9.99(10)^{099}$, the error bit is set, and a result of zero is returned.

AF4 Reciprocal Function

The AF4 reciprocal function finds the value of the reciprocal of a 6-digit BCD number and presents the result in a 6-digit BCD number.

$$\frac{1}{\pm xxx\ xxx.} = \pm .xxx\ xxx$$

If you try to find the reciprocal of ± 1, the result will read .999 999 with the appropriate sign.

How to Enter an AF4 Reciprocal Function

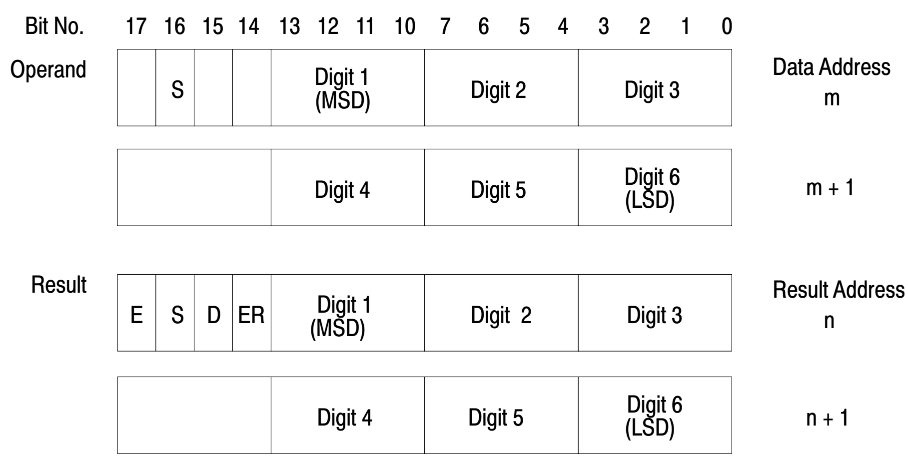
To program an AF4 reciprocal function, perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 34, the function number for an AF4 reciprocal function.

This entry identifies that the function entered is to perform an AF4 reciprocal calculation and that the processor use the data table format shown in Figure 3.43 when executed.

Figure 3.43
General AF4 Reciprocal Function Word and Digit Format



E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (Illegal Operand, 1 = Input is 0)
MSD = Most Significant Digit
LSD = Least Significant Digit

11511

3. Enter a data address and a result address.

If we choose a data address of 200 and a result address of 305, the AF4 establishes the data table format shown in Figure 3.44. The data address eventually contains the most significant three digits of the operand (the number whose reciprocal we seek). The next higher address, word 201, is reserved for the three least significant digits of the operand. The result address contains the most significant three digits of the result; the next address word 306, contains the least significant three digits of the result. The implied decimal points in the operand and the result are after the LSD and before the MSD respectively.

Figure 3.44
AF4 Reciprocal Function Format After Address Entry

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3	Data Address 200
					Digit 4	Digit 5	Digit 6 (LSD)	201
Result	E	S	D	ER	Digit 1 (MSD)	Digit 2	Digit 3	Result Address 305
					Digit 4	Digit 5	Digit 6 (LSD)	306

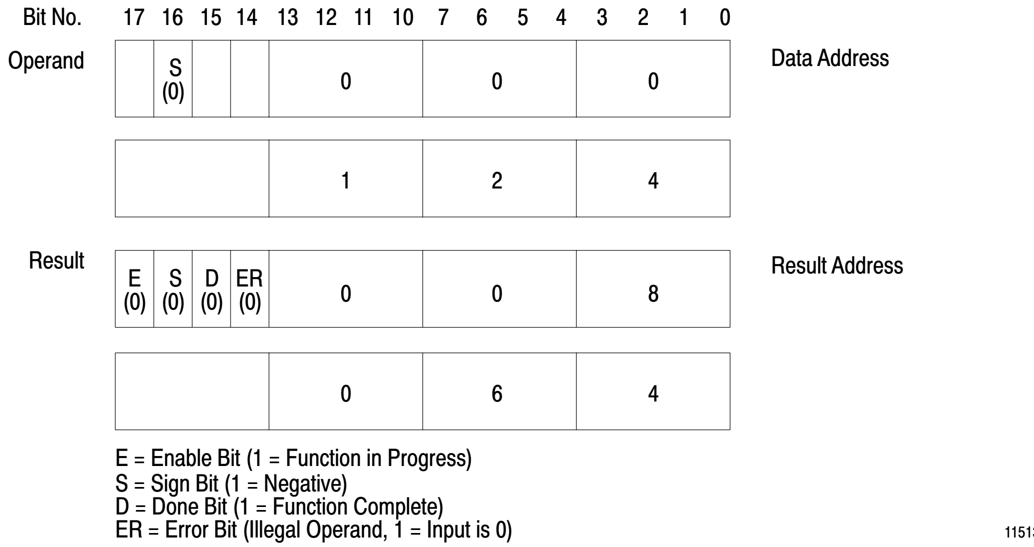
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (Illegal Operand, 1 = Input is 0)
MSD = Most Significant Digit
LSD = Least Significant Digit

11512

4. Enter the operand.

You can enter the operand from the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand 124 yields as its reciprocal the value .008064 as shown in Figure 3.45.

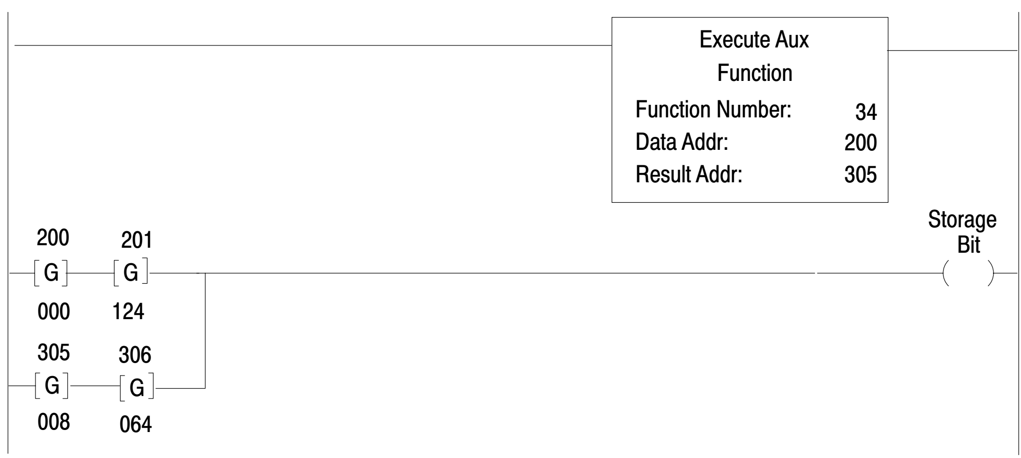
Figure 3.45
AF4 Reciprocal Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.45 shows one method of inserting input values and displaying input values and results of an AF4 reciprocal function. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests execution of an AF4 reciprocal function. The top branch of the second rung shows the 6-digit operand while the lower branch shows the 6-digit result.

Figure 3.46
AF4 Reciprocal Function Input and Result Display Rungs



Error Message

If you try to find the reciprocal of zero, the error bit (bit 145) is set and the result reads zero.

AF4 Trigonometric Function Sin xxx.

The AF4 sine function finds the sine of a 3-digit BCD angle. The input angle is in degrees. The AF4 presents the result as a 6-digit value with an implied decimal point after the most significant digit.

$$\sin xxx. = \pm x.xx\ xxx$$

How to Enter an AF4 Sine Function

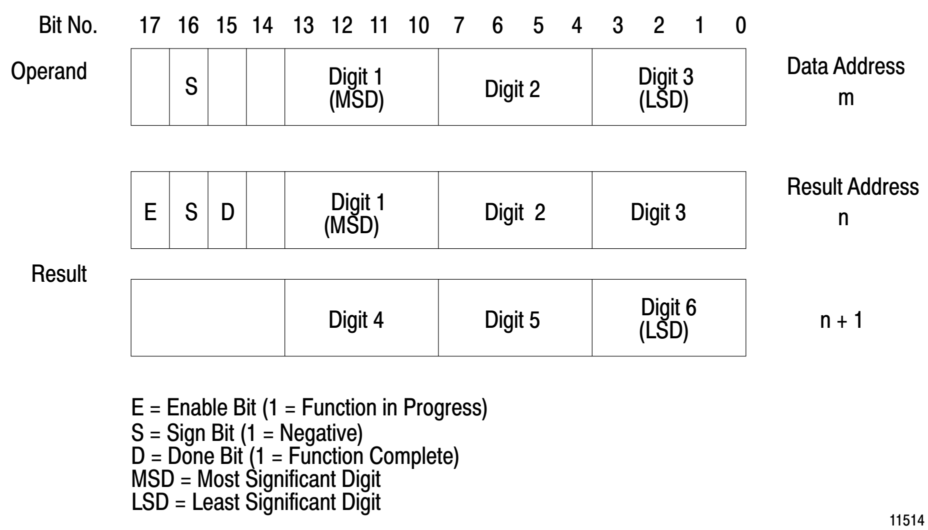
To program an AF4 sine function perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT} on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 35, the function number for the AF4 sine function.

This entry identifies that the function entered is to perform an AF4 sine calculation and that the processor use the data table format shown in Figure 3.47 when executed. The three BCD digits in the operand labeled digit 1 through 3 represent the angle with an implied decimal point after digit 3. The 6-digits in the result are the sine of the angle with an implied decimal point after digit 1.

Figure 3.47
General AF4 Sine Function Word and Digit Format



3. Enter a data address and a result address.

If we enter a data address of 205 and a result address of 310, the AF4 establishes the data table format shown in Figure 3.48. The data address, word 205, is reserved for the three digits of the angle whose sine we want. The result address, word 310, is reserved for the most significant three digits of the sine; the least significant three digits are stored in the next higher address, word 311.

Figure 3.48
AF4 Sine Function Format After Address Entry

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address 205
Result	E	S	D		Digit 1 (MSD)	Digit 2	Digit 3	Result Address 310
					Digit 4	Digit 5	Digit 6 (LSD)	311

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
MSD = Most Significant Digit
LSD = Least Significant Digit

11515

4. Enter an angle value in degrees (operand).

You can enter the angle from the keyboard of your industrial terminal or through ladder diagram functions. Entry of 080 for the angle produces the result sine 080^0 = 0.98480 (Figure 3.49).

Figure 3.49
AF4 Sine Function Format After Execution

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S (0)			0	8	0	Data Address 205
Result	E (0)	S (0)	D (1)		0	9	8	Result Address 310
					4	8	0	311

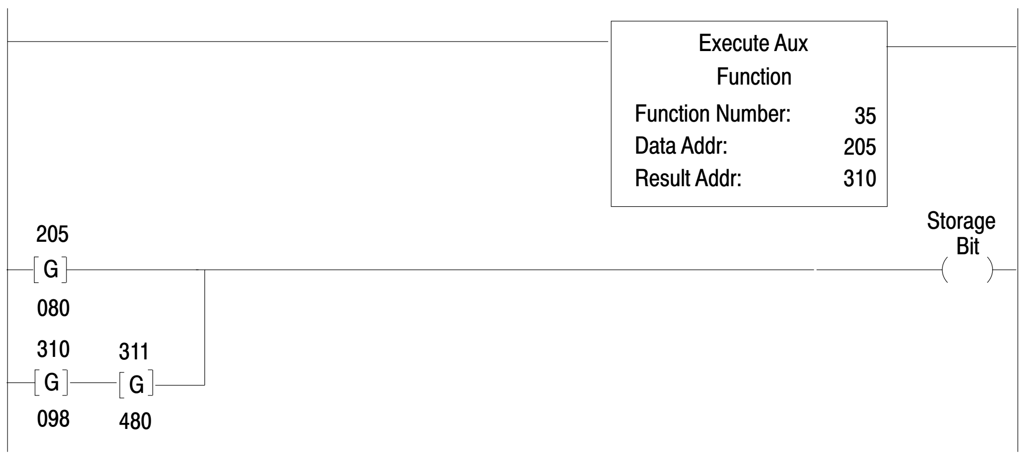
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)

11516

Entry and Display of Input and Result Values

Figure 3.50 shows one method for inserting the input angle and displaying the input and the result of an AF4 sine function. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests the AF4 sine function. The top branch of the second rung shows the angle value 080o in word 205. The lower branch shows the resultant sine 080^0 = 0.98480 in words 310 and 311 with an implied decimal point after the first digit.

Figure 3.50
AF4 Sine Function Input and Result Display Rungs



AF4 Trigonometric Function, Cos xxx.

The AF4 cosine function finds the cosine of a 3-digit BCD angle. The input angle is in degrees. The AF4 presents the result as a 6-digit value with an implied decimal point after the most significant digit.

cos xxx. = ±X.XX XXX

How to Enter an AF4 Cosine Function

To program an AF4 cosine function perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 36, the function number for the AF4 cosine function.

This entry identifies that the function entered is to perform an AF4 cosine calculation and that the processor use the data table format shown in Figure 3.51 when executed. The three BCD digits in the operand labeled digit 1 through 3 represent the angle with an implied decimal point after the third digit. The 6-digits in the result are the cosine of the angle with an implied decimal point after the first digit.

Figure 3.51
General AF4 Cosine Function Word and Digit Format

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address m
Result	E	S	D		Digit 1 (MSD)	Digit 2	Digit 3	Result Address n
					Digit 4	Digit 5	Digit 6 (LSD)	n + 1

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
MSD = Most Significant Digit
LSD = Least Significant Digit

11517

3. Enter a data address and a result address.

If we enter a data address of 205 and a result address of 310, the AF4 establishes the data table format shown in Figure 3.52. The data address, word 205, is reserved for the three digits of the angle whose cosine we want. The result address, word 310, is reserved for the most significant three digits of the cosine; the least significant three digits are stored in the next higher address, word 311.

Figure 3.52
AF4 Cosine Function Format After Address Entry

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address 205
Result	E	S	D		Digit 1 (MSD)	Digit 2	Digit 3	Result Address 310
					Digit 4	Digit 5	Digit 6 (LSD)	311

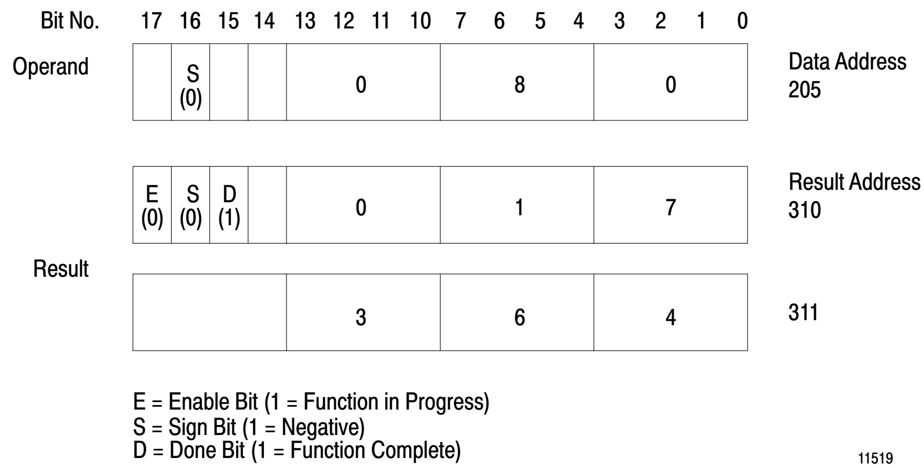
E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
MSD = Most Significant Digit
LSD = Least Significant Digit

11518

4. Enter an angle value in degrees (operand).

You can enter the angle from the keyboard of your industrial terminal or through ladder diagram functions. Entry of 080 for the angle produces the result cosine 080^0 = 0.17364 as shown in Figure 3.53.

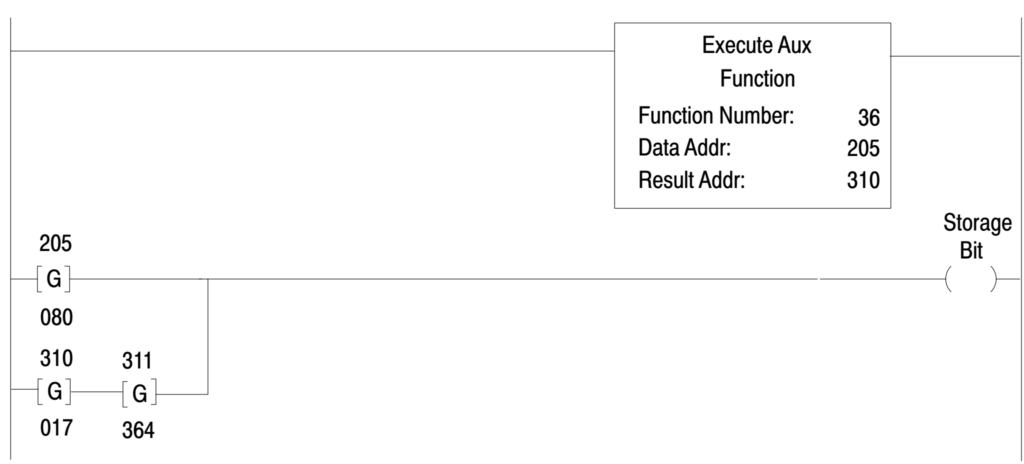
Figure 3.53
AF4 Cosine Function Format After Execution



Entry and Display of Input and Result Values

Figure 3.54 shows one method for inserting the input angle and displaying the input and the result of an AF4 cosine function. Although there are several techniques for accomplishing this, we chose get instructions. The first rung requests the AF4 cosine function. The top branch of the second rung shows the angle value 080^0 in word 205. The lower branch shows the resultant cosine 080^0 = 0.17364 in words 310 and 311 with an implied decimal point after the first digit.

Figure 3.54
AF4 Cosine Function Input and Result Display Rungs



AF4 Square Root Function

The AF4 square root function operates on a 3-digit BCD integer and gives the result in terms of a base number 4 and a power of 10, s, by which the base number is multiplied to obtain the resultant square root value. The equation is:

$+X^{1/2} = r(10)^{s}$

where:

x = XXX.

r = resultant base number = X.XXX

s = the exponent of 10 = x

How to Enter an AF4 Square Root Function

To program an AF4 square root function perform the following steps:

1. Press [SHIFT][EAF] or [SHIFT][SCT] on the keyboard of your industrial terminal. Figure 3.1 appears on the CRT.

2. Enter 37, the function number for an AF4 square root function.

This entry identifies that the function entered is to perform an AF4 square root calculation and that the processor use the data table format shown in Figure 3.55 when executed.

Figure 3.55
General AF4 Square Root Function Word and Digit Format

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address m
Result Base r	E		D	ER	Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Result Address n
s (Power of 10)		S			Digit 1 (MSD) (Always = 0)	Digit 2 (Always = 0)	Digit 3 (LSD)	n + 1

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Negative Operand)
MSD = Most Significant Digit
LSD = Least Significant Digit

11520

3. Enter a data address and a result address.

If we choose a data address of 200 and a result address of 305, the data table is as shown in Figure 3.56. The three digits of word 200 are reserved for the operand (the number whose square root we want). The result address (word 305) is reserved for the three digits of 4, the base number of the answer with an implied decimal point located after the MSD. The next higher address than the result address, (word 306) contains s, the power of 10. The implied decimal point in this number is after the LSD; the MSD and digit 2 are always zero.

Figure 3.56
AF4 Square Root Function Format After Address Entry

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S			Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Data Address 200
Result Base r	E		D	ER	Digit 1 (MSD)	Digit 2	Digit 3 (LSD)	Result Address 305
s (Power of 10)		S			Digit 1 (MSD) (Always = 0)	Digit 2 (Always = 0)	Digit 3 (LSD)	306

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Negative Operand)
MSD = Most Significant Digit
LSD = Least Significant Digit

11521

4. Enter the operand.

You can enter the operand from the keyboard of your industrial terminal or through ladder diagram functions. Entry of operand 144 produces the number 12 when the square root function is completed. Figure 3.57 shows how the operand and results are stored.

Figure 3.57
AF4 Square Root Function Format After Execution

Bit No.	17	16	15	14	13 12 11 10	7 6 5 4	3 2 1 0	
Operand		S (0)			1	4	4	Data Address 200
Result Base r	E (0)		D (1)	ER	1	2	0	Result Address 305
s (Power of 10)		S (0)			0	0	1	306

E = Enable Bit (1 = Function in Progress)
S = Sign Bit (1 = Negative)
D = Done Bit (1 = Function Complete)
ER = Error Bit (1 = Negative Operand)

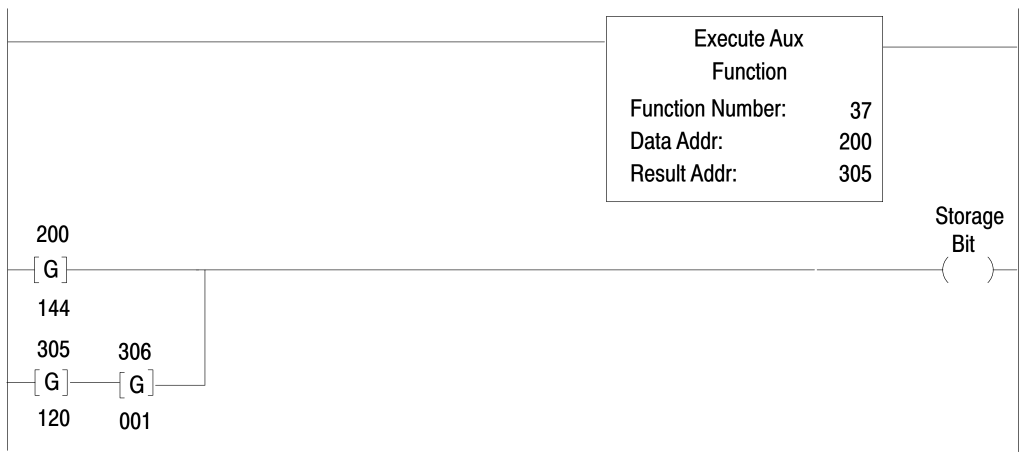
11522

Entry and Display of Input and Result Values

Figure 3.58 shows one method for inserting input values and displaying input values and the results of AF4 square root computations. Although there are several techniques for accomplishing this, we chose get instructions.

The first rung requests the AF4 square root function. The second rung displays in word 200 the number 144, whose square root is desired. It also shows the resulting square root (12) in the form of 1.20 in word 305 and in word 306 it shows the power of 10,001, by which 1.2 must be multiplied to obtain $(1.2)(10)^{001} = 12$.

Figure 3.58
AF4 Square Root Function Input and Result Display Rungs



Error Message

If you try to find the square root of a negative number, the error bit is set and the absolute value of the input number is used.

Index

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