HP 5342A Microwave Frequency Counter ⟷ HP-IB ⟷ HP 1000 Computer

Programming Guide

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Application Note 401-4

Device Introduction

The 5342A Microwave Frequency Counter[1] measures the frequency of signals in the range of 10 Hz to 18 GHz (resolution down to 1 Hz), with a basic sensitivity of −25dBm. Option 002 allows the 5342A to make amplitude measurements on signals from 500 MHz to 18 GHz with a resolution down to 0.1 dBm.

Option 011 gives the 5342A microwave counter the ability to converse with an intelligent HP-IB controller such as the HP 1000.

As an HP-IB talker/listener, the counter is a sophisticated instrument. It has internal triggering capability which facilitates the return of multiple measurements to the HP 1000 with minimum RTE operating system overhead. The 5342A also has service request (SRQ) capability which is compatible with the HP 1000 SRQ processing software. It is a medium-speed device on the bus and communicates in ASCII mode only. These HP-IB qualities are equal to and some surpass the HP-IB abilities of the 5345A, another very popular counter offered by HP.

The 5342A has a set of address switches on the rear panel positioned vertically. Note that the 5342A address cannot be read directly off these switches in binary (without some mental conversion in the process). Always set the 5342A to addressable when using it with the HP 1000. Study table 4-1 carefully before proceeding with the switch settings.

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[1]*This note should be used with the 5342A Operating and Service Manual (05342-90004) and Application Note 401-1 (5953-2800).*

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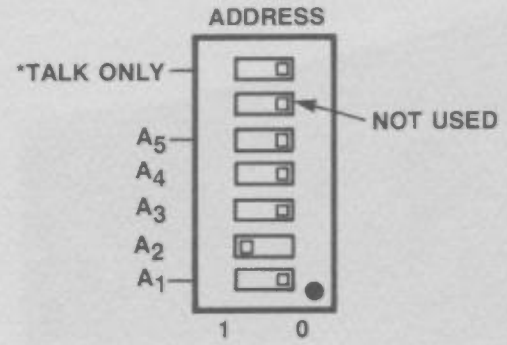
Table 4-1. 5342A Address Switch Selection



(Shown in addressable mode, and address 02)

***If the 5342A is in TALK ONLY mode and it is desired to return to the addressable mode, set TALK ONLY switch to 0 and press RESET on front panel.**

LU Assignment

One LU is needed for the 5342A. For example, if the HP-IB EQT number is 11 and the 5342A rear panel address is 3 octal, the LU assignment from File Manager will be:

```
:SYLU,17,11,3B
```

assuming LU 17 is available for use with the 5342A.

The BSCU[2] or system requests may be used to determine the assigned HP-IB EQTs and available LUs.

Buffering

The buffering option for the 5342A should not be allocated until the device has been configured and tested. To unbuffer EQT 11 from File Manager for example,

```
:SYEQ,11,UN
```

Time-out

The time-out value must be specified for the bus. Time-out should be used to detect an error condition (equipment malfunction) in the 5342A. This instrument differs from some other counters currently on the market in that it will return a measurement, whether or not an input signal is applied. If no input exists, the reading will be zero. This truly makes time-out an error situation. Remember, two important ideas about time-outs:

1. One time-out value is used for all the devices on a bus, and it must be a compromise for all of them.

2. Ample time must be allowed for the 5342A to return a measurement in a worst-case resolution situation, otherwise the time-out will occur before the measurement can be completed. Time-outs are device-dependent.

Configuration

The configuration word for the 5342A should be examined for possible changes to the default mode. DMA is not usually allocated for this device since its performance characteristics are usually adequate via the interrupt system. End-of-record (EOR) requirements default to their proper values. The SRQ priority bit should be left at its default value also. Because a time-out is truly an error condition, errors are usually catastrophic in the 5342A and are infrequent enough to be left for operating system handling. For this reason, the E bit in the configuration word can be left at its default value. See an example configuration word setup in figure 4-1.

Remote

The 5342A must be in remote before programming can take place. For example, the File Manager request,

```
:CN,17,16B
```

will set LU 17 to remote.

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[2]*See Appendix A for details concerning the Bus Status and Configuration Utility.*

```
          15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0
           S* R  D  I* J  O  P* E  X  X* X  X  X* X  X  X
          --*--------*--------*--------*--------*--------
           0  0  0  1  1  1  1  0  0  0  0  0  0  0  0  0
          --*--------*--------*--------*--------*--------
           0        1        7        0        0        0
          --*--------*--------*--------*--------*--------
S=0   I/O REQUEST NOT ABORTED ON AN SRQ.
R=0   NO I/O RESTART ATTEMPT AFTER SRQ.
D=0   DMA IS NOT ALLOCATED FOR THIS DEVICE.
I=1   REQUIRE AN EOI FROM DEVICE WITH THE LAST BYTE.
J=1
O=1   ISSUE AN EOI WITH THE LAST BYTE.
P=1
E=0   HP-IB ERRORS WILL ABORT THE PROGRAM.
```

Figure 4-1. Configuration Evaluation

NOTE

Originally, the 5342A was designed to assert the SRQ line each time a reading was ready to be sent back to the computer, no matter which modes had been programmed in the instrument. In some situations, this caused the HP 1000 to conduct a complete serial poll sequence each time a measurement was supplied by the counter.

A later production change to the instrument included a hardware jumper which makes SRQs an optional occurrence during the counter's measurement cycle. The Operating and Service Manual (part number 05342-90004) describes how this jumper is implemented.

The remainder of this section discusses when SRQs from the 5342A can be appropriately processed, and when they should be suppressed.

The 5342A can be easily verified for proper HP-IB operation from the RTE File Manager. An example systems preparations sequence can be performed as shown in figure 4-2.[3]

The 5342A's ability to respond to programming commands can be checked by sending it some programming information from File Manager as shown in figure 4-3.

There are two output modes in the 5342A. One mode continuously updates the 5342A output buffer whether or not the reading is actually taken by the HP 1000. The other mode waits with the reading until the HP 1000 requests it. The output modes are application-specific and should be considered carefully. (See table 4-2.)

When the 5342A is counting a signal that allows measurements to be obtained at a reasonably rapid rate (say, less than one second between measurements), the SRQs generated by the 5342A can either be removed or ignored.[4] Depending on the 5342A sampling mode, either a two-step or three step method may be used to program the device.

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[3] *The outcome of these operations can be checked with the BSCU in AN 401-1, Chapter 3.*

[4] *See the note at the beginning of this "Programming" section. SRQs from an HP-IB device are ignored when no devices are set up for program scheduling on the bus. In this case, no serial poll is initiated after the SRQ occurs.*

Table 4-2. Programming Codes

1. **Frequency Mode Select**

AUTO ..... AU
MANUAL ..... M

2. **Set Manual Center Frequency**

SMXXXXXE (X's represent nonfixed length data string of up to 5 characters. Decimal points cause entire string to be ignored. Plus signs and spaces are allowable. Number is in MHz and must be less than 18 GHz or will be ignored.)

Example: SM10000E for 10 GHz center frequency
SM775E for 775 MHz center frequency
SM+5250E for 5.25 GHz center frequency

3. **Amplitude Mode Select**

Frequency Offset off AM0
Amplitude on AM1

4. **Frequency Offset Mode Select**

Frequency Offset off OM0
Frequency Offset on OM1

5. **Set Frequency Offset**

SOM±XXXXX.XXXXXXE (X's represent nonfixed length data string representing offset frequency in MHz. Spaces are ignored.)

Example: SOM10.7E for 10.7 MHz positive offset
SOM−4000.25E for 4.00025 GHz negative offset.

6. **Amplitude Offset Mode**

Amplitude Offset off OB0
Amplitude Offset on OB1

7. **Set Amplitude Offset**

SOB±XX.XE (X's represent nonfixed length data string representing offset amplitude in dB. Spaces are ignored.)

Example: SOB−10.1E for 10.1 dB negative offset
SOB3.5E for 3.5 dB positive offset
SOB10E for 10 dB positive offset.

8. **Resolution**

1 Hz SR3
10 Hz SR4
100 Hz SR5
1 kHz SR6
10 kHz SR7
100 kHz SR8
1 MHz SR9

9. **Range**

10 Hz — 500 MHz L
500 MHz — 18 GHz ..... H

10. **FM/CW Mode**

CW mode C
FM mode ..... F

11. **Sample Rate**

Front panel sample rate T0
Hold T1*
Fast sample (no delay) T2
Sample then hold T3

*Send trigger command to start measurement. If 5342A is in remote and addressed to listen and other than Hold (T1), the trigger command causes the 5342A to automatically go to Sample then Hold (T3).

12. **Output Mode**

Output only when addressed ST1
Wait until addressed ST2

13. **Reset**

RE (Display is blanked and new measurement initiated. If in Hold (T1), then measurement is not completed but stays in Hold. Does not return control to local.)

14. **Automatic Offsets**

Automatic frequency offset ..... SOMB
Automatic amplitude offset ..... SOBB

15. **Check Mode**

SR1 (No input can be present at RF connector. Counter must be in SAMPLE RATE full ccw. Be sure to send RESET command (RE) before making other measurements.)

```
:SYLU,17,11,3B          Logical unit number 17.
                        Equipment table number 11.
                        Device address number 3 octal.

:SYEQ,11,UN             Unbuffer EQT 11.

:SYTO,11,1000           Time-out set to 10 seconds.

:CN,17,25B,17000B       Non-DMA I/O media.

:CN,17,16B              Set to remote.
```

Figure 4-2. Example System Preparation Sequence

```
:LL,17                  Set the list device

:AN,MSR9LT0ST1          (NOTE: the 5342A ignores blanks)
                        M     manual
                        SR9   resolution 1 MHz
                        L     10Hz-500MHz
                        T0    Front panel sample rate
                        ST1   Output only when addressed

:DU,17,0G               Dump measurements from the 5345A to the user terminal.

F  12345.789012E+06     Actual measurements.
F  12345.789012E+06
F  12345.789012E+06
F  12345.789012E+06
F  12345.789012E+06
F  12345.789012E+06
10>BR,FMG10             System prompt to stop measurements with BR command.

:                       File Manager prompt returns.
```

Figure 4-3. File Manager Test Procedure

The two-step method allows the 5342A to perform its own sampling automatically. (Figure 4-4 shows an example program.)

1. Program the front panel functions using those codes listed in table 4-2. The automatic sampling mode is active when the 5342A is turned on.
   No programming information is sent to the 5342A in figure 4-4 because it defaults to the correct programming state when turned on.

2. Make consecutive read requests from the user program to obtain the measurements.

The three-step method uses sampling by the HP 1000 user program:

1. Same as the two-step process, but the instrument must have been previously programmed for the manual sampling function "T1".

2. Before each measurement, send the "trigger" message to the 5342A from the user program.

3. Make consecutive read requests from the user program to obtain the measurements.

An example of this procedure in FORTRAN is shown in figure 4-5.

```
0001  FTN4,L
0002        PROGRAM R5342(3),09-07-78 (GWG) READ FROM 5342A
0003        DOUBLE PRECISION A                          Use a double precision variable for the
                                                        reading.
0004        INTEGER         ISTAT(2)                    Two words for the measurement type and
                                                        status.
0005        COMMON          ILU,ILST,IDLU               Parameters in common are supplied by
0006  C                                                 the function 'INPRM'.
0007        DATA NO/2HNO/
0008        IF(INPRM(ID).EQ.NO)GO TO 999                Get input LU and device LU.
0009  10    READ(IDLU,101)ISTAT,A                       Obtain the measurement type, status, and
                                                        reading.
0010  101   FORMAT(A2,A1,D17.6)                         Typical format for the 5342A.
0011        WRITE(ILU,109)ISTAT,A
0012  109   FORMAT(2A2,10X,D17.11)
0013        IF(IFBRK(IM).LT.0)GO TO 500                 Check the break flag to see if finished.
0014        GO TO 10
0015    999 WRITE(ILU,100)                              No device LU was specified to stop.
0016  100   FORMAT(/" R5342: ':RU,R5342,ILST,IDLU'")
0017   500  END
```

Figure 4-4. Two-step Method in FORTRAN

```
0001  FTN4,L
0002        PROGRAM R5342(3),09-07-78 (GWG) READ FROM 5342A
0003        DOUBLE PRECISION A                          Use a double precision variable for the
                                                        reading.
0004        INTEGER         ISTAT(2)                    Two words for the measurement type and
                                                        status.
0005        COMMON          ILU,ILST,IDLU               Parameters in common are supplied by
0006  C                                                 the function 'INPRM'.
0007        DATA NO/2HNO/
0008        IF(INPRM(ID).EQ.NO)GO TO 999                Get input LU and device LU.
0009        WRITE(IDLU,199)                             Setup 5342A for
0010   199  FORMAT("T1")                                manual triggering.
0011    10  CALL TRIGR(IDLU)                           Include the trigger.
0012        READ(IDLU,101)ISTAT,A                       Obtain the measurement type, status, and
                                                        reading.
0013  101   FORMAT(A2,A1,D17.6)                         Typical format for the 5342A.
0014        WRITE(ILU,109)ISTAT,A
0015  109   FORMAT(2A2,10X,D17.11)
0016        IF(IFBRK(IM).LT.0)GO TO 500                 Check the break flag to see if finished.
0017        GO TO 10
0018    999 WRITE(ILU,100)                              No device LU was specified to stop.
0019  100   FORMAT(/" T5342: ':RU,T5342,ILST,IDLU'")
0020   500  END
```

Figure 4-5. Three-step Method in FORTRAN

During a read request from the HP 1000, the 5342A will always return a combined status and type with the reading which must be broken up by a formatted read request or subroutine written by the user. For example, a measurement with no offset, and frequency only, would appear as,

```
F XXXXX.XXXXXXE+06 CRLF
```

where the X's represent 5342A digits.

One FORTRAN formatted read method for splitting the status/type from the actual measurement in FORTRAN is shown in figure 4-6.

```
      DOUBLE PRECISION A
      DIMENSION ISTAT(2)
      .
      .
      .
      READ (IDLU,101) ISTAT,A
      101 FORMAT(A2,A1,D17.6)
```

Figure 4-6. Separating the Status and Type from the Measurement.

SRQ Processing in the 5342A

When DVR37 with SRQ processing is included in the HP 1000 system software, performance may be degraded if SRQs are generated on a per reading basis and the readings are occuring rapidly. Consider what happens in the HP 1000 when the 5342A generates an SRQ:

A. If any device on the same bus is configured so that a user program will be scheduled when it generates SRQ:

   1. Only those devices set up for SRQ program scheduling will be serial polled.

   2. Each device so configured will be addressed to talk in the serial poll mode and return a status byte to the HP 1000 which will be stored in the HP 1000 device status word allocated to each HP-IB device.

B. If no devices (including the 5342A) are set up for SRQ program scheduling, no serial poll will occur.

When 5342A readings occur rapidly, using the SRQ capability is unnecessary. Making consecutive read requests from the user program is a sufficient method for inputting the measurement data (i.e., the user partition isn't tied up for long periods of time, waiting for readings). In this case, the 5342A SRQs should either be ignored (by not configuring other devices for SRQ program scheduling) or removed (by removing the 5342A internal SRQ jumper).

When 5342A readings occur intermittently over a long time period, the HP 1000 SRQ program scheduling facility may be used to:

1. Obtain the device status in the program which was automatically scheduled.

2. Read the measurement.

3. Save the measurements on a mass storage device.

This is a powerful technique to use when there is a significant delay period expected between 5342A readings. SRQ program scheduling frees the computer's resources to perform many other tasks while waiting for the counter's measurements.

The example program shown in figure 4-7 demonstrates how to do these operations in FORTRAN. Basically, the idea is to schedule a FORTRAN program "S5342" from a user terminal the first time, and supply it with the 5342A logical unit number and the LU number where the succeeding measurements will be recorded. Having this information, "S5342" sets up SRQ program scheduling for the 5342A LU. The program which will be scheduled on interrupt is "S5342". So, "S5342" will be scheduled 1 +N times, and N measurements will be obtained. See the comments with the listing in figure 4-7 for more details.

```
0001  FTN4,L
0002        PROGRAM S5342(3),09-12-78 (GWG) SRQ PROGRAM
0003  C
0004  C SYSTEM PREPARATIONS:
0005  C SET THE E BIT IN THE DEVICE CONFIGURATION WORD
0006  C UNBUFFER THE EQT
0007  C
0008  C THE RTE SAVE RESOURCES OPTION HAS BEEN
0009  C USED IN THIS PROGRAM. IT IS SCHEDULED
0010  C ONCE MANUALLY FOR SETUP, THEN 10 TIMES
0011  C BY 5342A INTERRUPTS.
0012  C
0013  C RMPAR IS CALLED 10 TIMES.
0014  C
0015        DOUBLE PRECISION A(10)                  Use a double precision variable for the
                                                    measurements.
0016        INTEGER IPM(5),IPRG(4),ISTT(2),ISTAT(10)
0017        COMMON  ILU,ILST,IDLU                   Function 'INPRM' supplies ILU and IDLU.
0018  C
0019        DATA    NO/2HNO/,LOOP/0/,
0020       &        IPRG/5,2HS5,2H34,2H2 /          Note that IPRG must contain the number
                                                    of characters.
0021        IF(INPRM(ID).EQ.NO)GO TO 999            Get run parameters.
0022        WRITE(ILU,100)IDLU
0023    100 FORMAT(" S5342A: SRQ PROGRAM SETUP",
0024       &       " IN PROGRESS FOR LU "I2"."/)
0025        CALL SRQ(IDLU,16,IPRG)                  Setup SRQ scheduling.
0026        IF(IERR(NN).LT.0) GO TO 20              Check for error.
0027        WRITE(IDLU,110)                         Program the 5342A.
0028    110 FORMAT("ST2")
0029     10 LOOP=LOOP+1                             Track the number of measurements taken.
0030        CALL EXEC(6,0,1)                        Terminate saving resources.
0031        CALL RMPAR(IPM)                         Get device status.
0032        ISTAT(LOOP)=IPM
0033        READ(IDLU,120)ISTT,A(LOOP)              Read the measurement.
0034    120 FORMAT(A2,A1,D17.6)
0035        IF(LOOP.EQ.10) GO TO 20
0036        GO TO 10
0037    999 WRITE(ILU,130)                          No device was specified.
0038    130 FORMAT(" :RU,S5342,ILST,IDLU"/)
0039        STOP
0040     20 DO 30 LOOP=1,10                         Print the measurements.
0041     30 WRITE(ILU,140)ISTAT(LOOP),A(LOOP)
0042    140 FORMAT(5X,I6,5X,D17.11)
0043        END
```

Figure 4-7. SRQ Program

Performance

Chapter 4 of Application Note 401-1 describes the performance theory of HP-IB in the RTE operating system. Shown in Chapter 5 are actual performance programs which were used to experimentally determine the number of readings the 5342A can obtain per second and the system utilization during each measurement.

Some of the factors which determine measurement times are shown in figure 4-8.

1. The 5342A programming state
   - resolution
   - sampling mode
   - auto or manual
   - frequency
   - frequency offset
2. The type of RTE input
   - a simple RTE EXEC call with no ASCII conversion, or
   - a formatted read using a formatting routine
3. The operating system overhead
   - see Chapter 5, AN 401-1

Figure 4-8. Factors Which Determine Measurement Times

The 5342A programming state is application-specific. Increasing accuracy by setting higher resolution causes longer measuring times and fewer readings per second.

When no ASCII to binary conversion within the computer is required, a simple ASCII input EXEC request may be used which requires less computer time. This method is used in data logging situations, or when the information is to be stored for processing later. Excluding other factors, this method will improve measurement speed.

The operating system overhead is not easily controllable by the user. The number of programs in the timelist may be changed on-line, but the characteristics assigned at system generation cannot.

The key to improving measurement speed is to determine whether the times are a factor of the instrument or the computer, and decide whether the trade-offs can be tolerated.

The graphic performance results are shown in figure 4-9. Two pair of plots are shown. One shows time vs number of readings for HP 1000 input using a formatted read and the FORTRAN formatter. The corresponding system utilization curve is also shown. The second pair of curves demonstrates the performance improvement when ASCII to binary conversion is unnecessary (i.e., when RTE EXEC calls can be used to obtain the measurements).

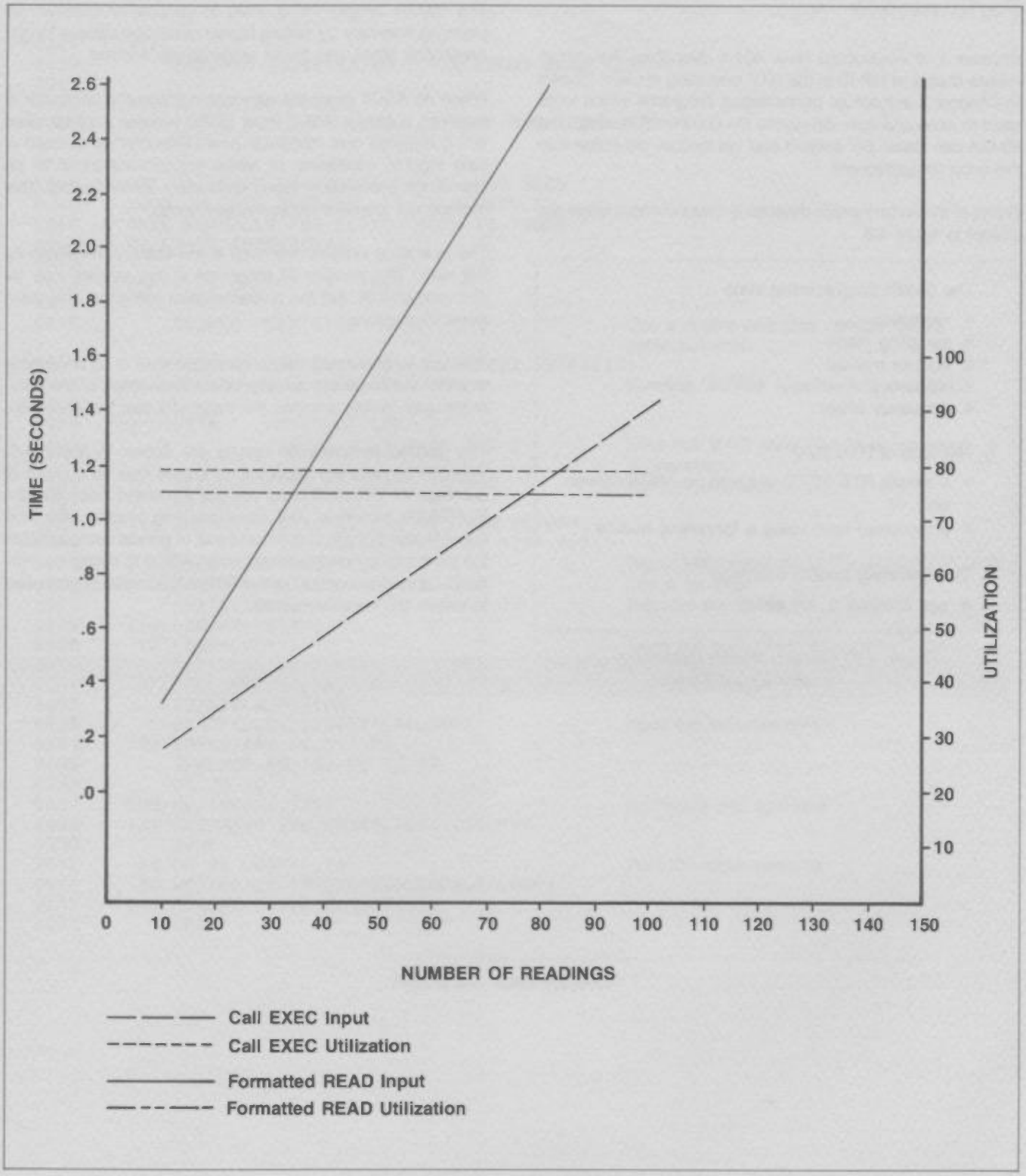

Figure 4-9. 5342A Performance

EXEC Call Input*		
Number of Readings	Time (Seconds)	% Utilization
10	.14070	79.63
20	.28141	79.61
30	.42211	79.59
40	.56262	79.60
50	.70332	79.60
60	.84403	79.59
70	.98473	79.59
80	1.12524	79.58
90	1.26614	79.59
100	1.40684	79.59

Example FORTRAN Statements from the Performance Program

```
0057 C
0058 C ================================
0059 C ENTER USER STATEMENTS FOR TEST HERE.
0060       DO 100 IJ=1,ILN
0061
0062
0063       CALL EXEC(1,IDLU,IBUF,10)
0064 C USER STATEMENTS FOR TEST END HERE.
0065 C ================================
```

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FORTRAN Formatted Input*		
Number of Readings	Time (Seconds)	% Utilization
10	.31872	75.45
20	.63725	75.45
30	.95577	75.43
40	1.27449	75.43
50	1.59302	75.43
60	1.91193	75.43
70	2.23046	75.43
80	2.54918	75.43
90	2.86790	75.43
100	3.18642	75.42

Example FORTRAN Statements from the Performance Program

```
0015       DOUBLE PRECISION A
 .
 .
 .
0060 C
0061 C ================================
0062 C ENTER USER STATEMENTS FOR TEST HERE.
0063       DO 100 IJ=1,ILN
0064       READ(IDLU,144)ISTAT,A
0065 144   FORMAT(A2,A1,D17.6)
0066 C USER STATEMENTS FOR TEST END HERE.
0067 C ================================
0068 C
```

**5342A Performance 9-14-78 MLSR9T2ST1 350 nsec Memory via Interrupt System Overhead 2.83% RTE-IV*

Figure 4-9. 5342A Performance (Continued)

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