5345A Electronic Counter
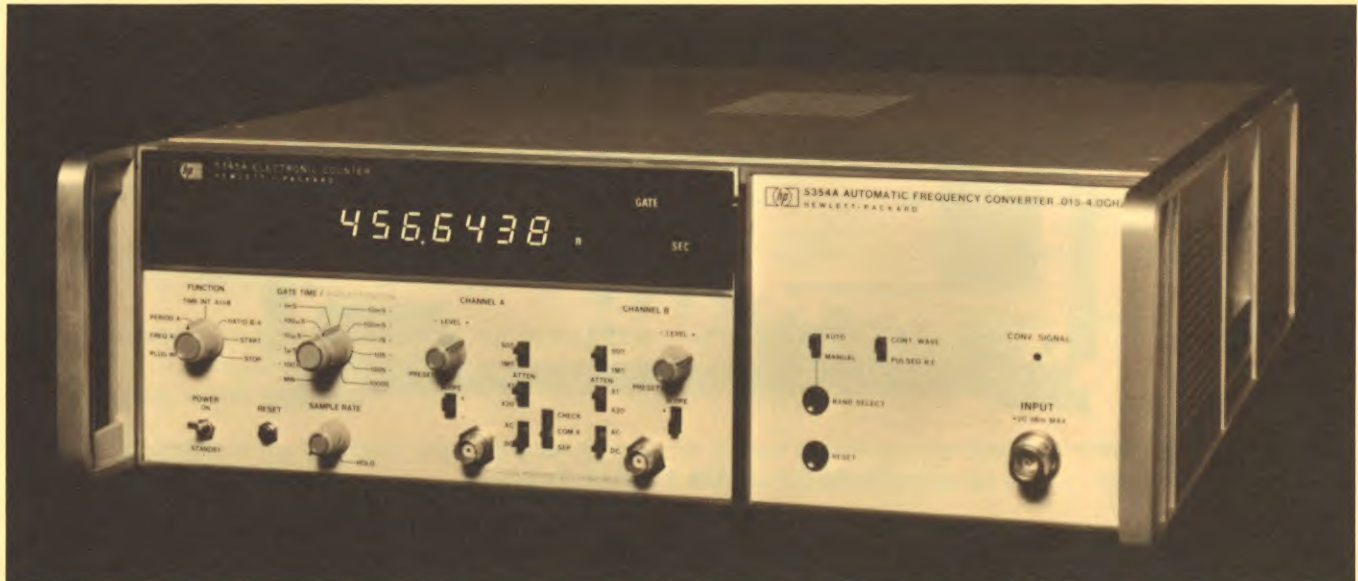
HP-IB/HP 1000 Programming Example

HEWLETT hp PACKARD

HP-IB

DATA SYSTEMS DIVISION

Device Introduction

The Hewlett-Packard Model 5345A Electronic Counter is a reciprocal counter capable of direct measurements to 500 MHZ. The counter's ability to accept plug-in accessories extends its inherent capabilities and provides for a variety of additional measurements.

The instrument measures frequency, period, period average, single-shot time interval, time interval average, and ratio. It also provides a totalize function, whereby two signals can be simultaneously totalized with the displayed result being the sum of the difference in the total number of counts. Using the 5245A series of plug-ins extends the frequency range to 18 GHZ.

The 5345A is a device which is both a talker and a listener on the bus. The CHECK/COM A/SEP switch as well Function and Gate Time can be programmed when the 5345A is operated as a listener on the HP-IB.

The 5345A Option 11 allows all front and rear panel switch functions, except those on the input amplifier to be programmed.

It can function as a talker and send readings back to the computer. The 5345A has two talk addresses, one for sending readings back to the computer in normal ASCII format, and the other talk address for an unprocessed ASCII computer dump mode. (No computations are performed in the 5345A in this mode.)

Addressing

Before the 5345A can send output data or accept program information, it must be addressed to TALK or LISTEN. Five switches are available on the rear panel of the 5345A right above the HP-IB connector (as shown in figure 3-1). The TALK ONLY switch farthest to the left should always be down (off) when the 5345A is connected to the HP 1000.

Two addresses are always set on the rear panel. Notice that switch A1 is missing from the rear panel switch layout. This ensures that two device addresses are available on the 5345A; the even address would be assumed if A1 were 0 and the odd address would be assumed if A1 were 1.

The 5345A has two talk addresses: one for sending readings back to the computer in normal ASCII format (standard output mode), and the other talk address (the next higher odd number above its even address setting) for what is called "computer dump output mode." This mode outputs the reading in an unprocessed ASCII format. Suppose A2 is set to 1 and A3 is set to 1, A4=A5=0. The octal address will be as shown in figure 3-2.

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[1]*This note should be used in conjunction with the 5345A Operating and Service Manual (part no. 05345-90025) and Application Note 401-1 (5953-2800).*

ADDRESS SWITCHES
TALK ONLY SWITCH

Figure 3-1. 5345A Address Switches

```
A5      A4      A3      A2     [A1]
 0       0       1       1      0
--------        ----------------

     0               6              OCTAL     (Normal Mode)

OR

 0       0       1       1      1
-------         --------------
     0               7              OCTAL     (Computer Dump Mode)
```

Figure 3-2. The 5345A Has Two Address Modes

System Preparations

LU Assignment

To set up the 5345A for normal ASCII measurements, assuming LU 20 on EQT 11:

:SYLU,20,11,6

use an even address.

To set up the 5345A for computer dump mode ASCII measurements:

:SYLU,20,11,7

use an odd address.

Output Buffering

Output buffering should be turned off while checking out the 5345A. The user must decide whether or not buffering is to be used in the final process based on whether the user program will handle errors and time-outs. (Buffering must be turned off if error conditions will be handled by the user program.)

Time-Out

The 5345A will not return a reading in some cases (for example, a discontinuous input waveform). In this case, a time-out may not be an error condition and should be handled by the user program. The time-out value on the EQT should be considered carefully when a 5345A is to be connected.

Suppose the 5345A has been programmed to obtain a measurement and a read request is pending in the HP 1000. If,

a. the time-out was set to 3 seconds,

b. the device LU has been configured so that the user program will handle time-out errors, and

c. the input waveform to the counter is discontinuous for more than 3 seconds,

then at the end of three seconds, control will return to the user program. At this point the condition can be checked and the appropriate action taken.

When time-out errors are declared to be handled by the system, however, control will not return to the user program after 3 seconds, but instead will return to the operating system. The 5345A will be set "down", and the user program will be put into the general wait list until the trigger source is made continuous. Once the condition is corrected, the LU must again be enabled using the "UP" operator request[2]. A time-out should always be specified for the 5345A or it may disable the LU and the user program indefinitely.

Configuration Word

The device configuration word for the 5345A defaults to the correct value when DMA is allocated.

`:CN,IDLU,25B,37000B` will allocate DMA from FMGR.

This is especially desired when gate time's less than 10 msec are used.

Make special note of the following characteristics:

1. The 5345A is capable of halting the operating system clock when non-DMA is used with gate times less than 10 msec. If this is undesirable, allocate DMA.

2. 5345A SRQ'S require special handling with the HP 1000. See the "Programming" section.

3. End of record processing is standard in the 5345A and will need no reconfiguration.

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[2]*Refer to the RTE Operating Manual (for RTE IV, part number 92067-90001).*

Remote

The bus must be set to remote and the characters "E8" must be sent before 5345A programming can begin.

```
:CN,IDLU,16B. .remote enable the bus.
:LL,IDLU. . . .set list device to the 5345A
:AN,E8. . . . .send remote command to 5345A
```

Figure 3-3. Remote Enable the 5345A

Programming

Before explaining the details of 5345A programming, the following points should be clearly understood.

There are three HP-IB options available for the 5345A, options 10, 11, and 12. Each of the models handles SRQ processing differently.

OPTION 10 — cannot assert the SRQ line in any situation. This option is not programmable and is used when it is only desired to output readings to a "listen only" device, such as an HP-IB printer.

OPTION 11 — is the most popular HP-IB option. It will assert the SRQ line in the wait until addressed (E:) mode. This option does not recognize 'SPE' and 'SPD' however, and does not output status information while in the SRQ state. The 5345A option 11 responds to the Untalk and Unlisten universal commands. It does NOT respond to the following universal commands: Local Lockout (LLO), Group Execute Trigger (GET), Device Clear (DCL), Serial Poll Enable (SPE), and Serial Poll Disable (SPD). The 5345A option 11 should not be allowed to generate SRQ's when DVR37/SRQ has been implemented.

OPTION 12 — will assert the SRQ line in the wait until addressed (E:) mode. This model recognizes 'SPE' and 'SPD' but does not output status information while in the SRQ state. The option 12 counter should not be allowed to generate SRQ's when DVR37/SRQ has been implemented in the system.

SUMMARY: The 'wait until addressed' (E:) mode should be used only when DVR37 without SRQ handling has been implemented in the HP 1000 operating system, or when no other devices will be asserting SRQ on the same bus with the 5345A.

2 FUNCTION (F0, F1, F2, F3, F4, F5, F6)

4 GATE TIME (G4, G3, G2, G1, G0, G?, G>, G=, G<, G;, G:, G9, G5)

5 DISPLAY POSITION (D;, D:, D9, D8, D?, D>, D=, D<, D3, D2, D1, D0)

8 LEVEL (NOT APPLICABLE)

9 INPUT IMPEDANCE SWITCH (NOT APPLICABLE)

10 ATTEN SWITCH (NOT APPLICABLE)

14 INPUT IMPEDANCE SWITCH (NOT APPLICABLE)

15 ATTEN SWITCH (NOT APPLICABLE)

17 LEVEL (NOT APPLICABLE)

18 SLOPE (NOT APPLICABLE)

19 INPUT JACKS (NOT APPLICABLE)

16 COMPLING SWITCH (NOT APPLICABLE)

12 INPUT AMPLIFIER CONTROL (E7, E?)

11 COUPLING SWITCH (NOT APPLICABLE)

13 INPUT JACKS (NOT APPLICABLE)

7 SLOPE (NOT APPLICABLE)

6 SAMPLE RATE (E1E4, E1E<, E9, J1)

3 RESET (I1)

1 POWER (NOT APPLICABLE)

Figure 3-4. 5345A Programmable Functions

Table 3-1. 5345A Programming Commands (Option II)

1. Function — ASCII

  a. Plug In F2
  b. Frequency A .... FØ
  c. Period F1
  d. Time Interval A to B F3
  e. Ratio B/A F5
  f. Start F4
  g. Stop F6

2. Accum Mode Start/Stop (If F4 or F6)

  a. A+B .... E=
  b. A–B E5

3. Remote Gating

  a. External Gate .... E;
  b. Internal Gate E3

4. Gate Time

  a. 10000 sec G4
  b. 1000 sec G3
  c. 100 sec G2
  d. 10 sec G1
  e. 1 sec .... GØ
  f. 100 ms .... G?
  g. 10 ms .... G>
  h. 1 ms .... G=
  i. 100 µs .... G<
  j. 10 µs .... G;
  k. 1 µs .... G:
  l. 100 nsec G9
  m. Min G5

5. Input Amplifier Control

  a. COM A or Separate E7
  b. Check .... E?

6. Sample Rate Selection

  a. Maximum Sample Rate (~100 msec) E1E4
  b. Minimum Time (1–5 msec) .... E1E<
  c. HOLD E9

7. Output Mode — ASCII

  a. ONLY IF Addressed E2
  b. WAIT Until Addressed .... E:

8. Display Position
(Digits from E in Data String)
(Digit Position Defined from Right to Left, Decimal Point on Right Side of Digit)

  a. 0 Digits .... D;
  b. 1 Digit .... D:
  c. 2 Digits D9
  d. 3 Digits D8
  e. 4 Digits .... D?
  f. 5 Digits .... D>
  g. 6 Digits .... D=
  h. 7 Digits .... D<
  i. 8 Digits D3
  j. 9 Digits D2
  k. 10 Digits D1
  l. Auto Position + Auto Suffix Multiplier .... DØ

9. Display Multiplier Suffix (If other than DØ)

FREQ.	PERIOD/TIME INTERVAL	START/RATIO	ASCII
GHz	nsec	G	C7
MHz	µsec	M	C6
kHz	msec	k	C5
Hz	sec		C4
mHz	ksec		C3

    ASCII

10. Remote Program Initialize I2

11. Local — Remote

  a. Switch to Local .... EØ
  b. Switch to Remote E8

12. Reset Command I1
(End of 100 ms reset pulse initiates measurement cycle)

13. Sample Trigger Command (If E9) J1

RESET PUSHBUTTON/POWER UP/I2 PROGRAM conditions are FØ, GØ, DØ, E7, EØ, E2, E3, E1, E4, E5

The 5345A can be programmed using "WRITE" or "PRINT" statements or the "AN" message from File Manager. (See figure 3-4.)

For example, from file manager, the programming codes in figure 3-6 could be sent to the 5345A. (See figure 3-5 for an explanation of the 5345A programming codes.)

(E2) **Only if addressed** — During the counter's operating algorithm, the counter checks to see if it has been addressed to talk (a pending read statement in the HP l000). If it hasn't, it continues taking measurements.

(E:) **Wait until addressed** — During its operating cycle, the counter checks to see if it has been addressed to talk (a pending read statement in the HP l000). If it hasn't, the counter waits with its current measurement (stored in its output buffer) until it has been addressed. When it is addressed, it outputs the reading in its buffer and is enabled to begin another measurement.

When the current measurement is ready for output the SRQ line is asserted. In an HP 1000 with DVR37 and SRQ processing capability, the 5345A may hang up the bus. This happens because the counter does not recognize the serial poll mode, which is a procedure automatically implemented by DVR37 with SRQ handling.

(I1) **Reset** — The reset command causes the current measurement cycle to be terminated and a new cycle to begin (i.e., it also acts as a sample trigger). After sending any new programming codes, I1 must terminate the code string to ensure that a measurement cycle is begun using the new codes. If I1 is given when the counter is in the 'WAIT until addressed' mode (E:), the counter will immediately go to an output cycle and output all zeros. Only when the output is complete and sample trigger occurs will a new measurement begin. Hence, under these conditions, the first reading into the computer (consisting of all zeros) must be discarded.

(I2) **Remote program initilize instruction** — Loads the remote program storage cells with the initial conditions of instrument on power up or front panel reset. The stored program is F0, G0, D0, E7, E0, E2, E3, E1, E4, E5. They are:

F0	–	Frequency A
G0	–	1 sec gate time
D0	–	Auto display position
E7	–	COM A or SEP (depending on front panel position)
E0	–	Local operation
E2	–	Output only if addressed to talk
E3	–	Internal Gate
E1	–	Sample rete not hold
E4	–	Sample rate 50 msec time
E5	–	A-B Start mode

Figure 3-5. 5345A Programming Codes

```
:SYLU,30,7,2  ...... Assign LU 30 to The 5345A.
:CN,30,16B    ...... Put the device in remote.
:LL,30        ...... Send a message to LU 30.
:AN,I2E8G>I1  ...... Program 5345A (1 second
                     gate time default), remote
                     operation initilize.
```

Figure 3-6. Setting up the 5345A from File Manager

Standard Output Mode

Figure 3-7 shows a typical FORTRAN program which can take measurements from the 5345A. The following points are important:

1. 5345A "reset" is achieved by sending I2E8I1.

2. After a reset, a dummy reading must be taken to insure that consecutive readings will be in order.

3. Output mode is "E2".

4. Free field input using the FORTRAN Formatter has been implemented. Note that a DO LOOP must be used to read values into an array.

```
      DO 10 I=1,20
   10 READ(IBLU,*)A(I)
```

Note that the 5345A can use an internal trigger to put measurements into its internal buffer, and will output the current buffer contents when addressed to talk. If the HP 1000 is reading measurements slower than the 5345A is sampling, some measurements will be skipped over and lost (the 5345A buffer will be overlayed with new samples). This is normal operation for the E2 mode.

The counter has a buffer between the actual counter registers and the HP-IB. This buffer contains zeros during power-up, and the previous reading during operation. Care should be taken that the computer gets the desired reading from the counter and not the previous reading

When addressed to output, the 5345A sends a space or minus, up to 11 digits of data, decimal point, the multiplier to make the reading (mHz, Hz, kHz, MHz, GHz, or ksec, sec, msec, microsec, nsec) and carriage return linefeed. When "programming manual display," all fictitious (filler) digits are output as zeros.

```
0001    FTN4,L
0002         PROGRAM T5345(3),05-01-78 (GWG) FREE FIELD INPUT
0003    C
0004    C  RU,T5345,ILST,IDLU
0005    C
0006         REAL            A(20)
0007         COMMON ILU,ILST,IDLU
0008         DATA NO/2HNO/
0009         IF(INPRM(ID).EQ.NO) GO TO 999
0010         WRITE(IDLU,1)
0011    1    FORMAT("I2E8I1G9")
```
'G9' indicates 100ns gate time. 'I2E8I1' resets the 5345A. 'E2' is the default output mode. 'E:' should not be used unless SRQ'S are ignored.

```
0012         READ(IDLU,*) DUMY
```
Note that a dummy reading must be taken after the 5345A has been reset.

```
0013         DO 4 I=1,20
0014    4    READ(IDLU,*)A(I)
```
Free field input may be used. A separate loop is needed because each reading is terminated by a 'CRLF' instead of delimited by a comma.

```
0015         WRITE(IDLU,2)A
0016    2    FORMAT(4(/,5E14.6))
0017  999    END
```

Figure 3-7. 5345A Measurement Program

Computer Dump Output Mode

In the computer dump mode, the 5345A outputs a measurement in an unprocessed format as shown in the operating and service manual.

The first 16 byte value is the number of events, or in the case of a periodic waveform, the number of cycles in a set period. The second 16 byte value is the number of 5345A counts (2×10^{-9} sec/count) during the same period (figure 3-8).
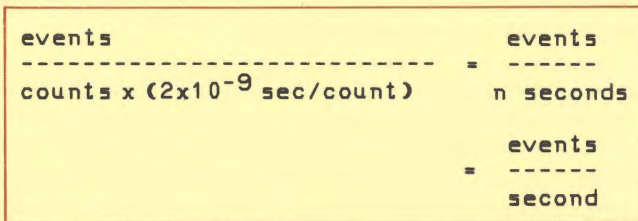
```
events
----------------------------      events
                             =     ------
counts x (2x10⁻⁹ sec/count)        n seconds


                                   events
                             =     ------
                                   second
```

Figure 3-8. 5345A Counting Format

The 5345A gate adjusts the time period over which the events are averaged. Figure 3-9 contains an example program and a subroutine showing how the computer dump mode may be implemented. A doubly subscripted array (IRED) dimensioned eight (2 * 8 = 16 bytes) by two hundred (16 words per reading for 100 readings) is used to separate each 16 byte value. There are 32 bytes (16 words) per reading. Because there is no end of record terminator in computer dump mode, a fixed length ASCII EXEC read request is made to input the data (line 29).

The computer dump data is processed using a FORTRAN subroutine 'CFREQ' which converts the ASCII data to binary and returns the frequency in the variable 'FREQ'. 'REDS' is a real array containing the converted 16 byte ASCII values.

Refer to the 5345A Operating and Service manual for additional information on the computer dump mode.

```
0001   FTN4,L
0002          PROGRAM TDUMP(3),
0003        &5-16-78 (GWG) DUMP OUTPUT MODE 5345A
0004   C
0005   C  RU,TDUMP,ILST,IDLU
0006   C
0007          INTEGER   IRED(8,200),IBUF(1603),IREG(2),YES
0008          REAL      REDS(200),FREQ(100)
0009   C  IBUF(X) WHERE X= 16 * (# OF READINGS) + 3
0010   C  IRED(8,Y) WHERE Y= 2 * (# OF READINGS)
0011   C  REDS(Y) WHERE Y= 2 * (# OF READINGS)
0012   C  FREQ(N) WHERE N= # OF READINGS
0013   C
0014          EQUIVALENCE (REG,IREG,IA),(IREG(2),IB)
0015          EQUIVALENCE (IBUF,IRED)
0016          COMMON ILU,ILST,IDLU
0017          DATA YES/2HYE/
0018   C
0019   C      IF(INPRM(ID).EQ.YES) GO TO 10           Obtain input parameters.
0020          WRITE(ILU,100)
0021   100    FORMAT(" :RU,TDUMP,ILST,IDLU"/)
0022   C
0023          STOP
0024   C
0025   C
0026   C
0027   C INPUT 100 READINGS FROM 5345A
0028   C
0029    10 REG=REIO(1,IDLU,IBUF,1600)                 Fixed length ASCII input
```

Figure 3-9. 5345A Computer Dump Mode

```
0030        IF(IB.LT.1600)WRITE(ILU,102)IB
0031  102   FORMAT(/" TDUMP: PREMATURE ENDING ON INPUT, ",
0032        &"ONLY "I6" WORDS.")

0033        CALL CFREQ(IRED,REDS,100,FREQ)          Compute the readings.

0034        WRITE(ILU,111)(FREQ(IN),IN=1,100)
0035  111   FORMAT(5E14.6)
0036        END
0037  C
0038  C
0039  C
0040        SUBROUTINE CFREQ(IRED,REDS,N,FREQ),
0041        &5-16-78 (GWG) CMPUT FREQ. 5345A
0042  C
0043  C CALL CFREQ(IRED,REDS,N,FREQ)
0044  C
0045  C     IRED = ASCII INPUT BUFFER
0046  C     REDS = REAL DOUBLE WORD BUFFER
0047  C        N = 2 * (# OF READINGS)
0048  C     FREQ = COMPUTED FREQUENCY BUFFER
0049  C
0050        DIMENSION IRED(8,1),REDS(1),FREQ(1)
0051        J2=0
0052        DO 1000 J=1,N*2,2
0053        J2=J2+1
0054        REDS(J)=0
0055        REDS(J+1)=0
0056  C
0057        LL=0
0058        DO 2000 L=1,8
0059        IH=IAND(IRED(L,J)/377B,17B)
0060        IL=IAND(IRED(L,J),17B)
0061        REDS(J)=REDS(J) + IH*10.**LL + IL*10.**(LL+1)
0062        IH=IAND(IRED(L,J+1)/377B,17B)
0063        IL=IAND(IRED(L,J+1),17B)
0064        REDS(J+1)=REDS(J+1) + IH*10.**LL + IL*10.**(LL+1)
0065  2000  LL=LL+2
0066        FREQ(J2)=REDS(J)/(REDS(J+1)*2.E-9)
0067  1000  CONTINUE
0068        RETURN
0069  C
0070        END
```

Figure 3-9. 5345A Computer Dump Mode (Continued)

Performance

The 5345A measurement performance in the HP 1000 environment is dependent upon the type of user program input.

Several modes of input are available in the HP 1000. The two modes chosen for these performance measurements are:

1. FORTRAN free field input. Input is automatically formatted and ASCII values are converted to real numbers (binary values).

2. "CALL EXEC" takes ASCII input directly into memory. The 5345A measurements are simply input and no processing is performed.

Two modes of output are available from the 5345A:

1. Standard output mode (even address) where 11 ASCII characters are sent plus a carriage return linefeed.

2. Computer dump output mode (odd address) where 32 ASCII characters are sent after each measurement without the end of record terminator (carriage return linefeed).

The most efficient method which optimizes performance speed, is to set the counter to internal trigger, perform 'EXEC' calls for input, and use the 5345A in the computer dump mode. The user input buffer should be made as large as feasible, because only one 'EXEC' request will input all of the measurements. This method is a real advantage when gate times less than 10 msec are used and DMA is allocated. The major I/O overhead is produced during the 'EXEC' setup which shows why this method is efficient. The actual transfer (with DMA) per byte is small in comparison. The "Programming" section in conjuction with figure 3-9 shows how to process the input data once it is in the user buffer.

DMA should be allocated to the 5345A for repetitive measurements when gate times less than l0 msec are used. A degradation in system time keeping may occur if DMA is not allocated.[3]

Non-DMA mode may be used when gate times longer than 10 msec are implemented. One may also choose to select the non-DMA mode if DMA channels are heavily allocated to other devices in the system.

Figure 3-10 shows combined performance curves for sample measurement rates and corresponding system utilization using an HP 1000 series F computer and high performance memory. The programming code for the counter is shown in figure 3-11. For information on how to produce these curves by experimentation, see Application Note 401-1, Chapters 4 and 5. Included in Chapter 5 is the performance program used to obtain the measurement curves.

The variable 'ILN' (line 65, figure 3-11) varies each iteration to produce the values for the "EXEC" curve shown in figure 3-10.

The performance curves for free field input to the computer (using the FORTRAN Formatter) are shown in figure 3-12. See the programming code for these measurements in figure 3-13.

```
0046   C
0047   C=======================================
0048   C ENTER USER STATEMENTS OUT OF TEST HERE.
0049   C
0050         WRITE(IDLU,5000)
0051   5000  FORMAT("I2E8I1G5E1E<")
0052         ILN=ILN*32
0053   C
0054   C
0055   C=======================================

0062   C
0063   C=======================================
0064   C ENTER USER STATEMENTS FOR TEST HERE.
0065         CALL EXEC(1,IDLU,HBUF,ILN)
0066   C USER STATEMENTS FOR TEST END HERE.
0067   C=======================================
0068   C
```

**Figure 3-11. Programming Code
for Dump Mode Performance**

```
0047   C=======================================
0048   C ENTER USER STATEMENTS OUT OF TEST HERE.
0049   C
0050         WRITE(IDLU,5000)
0051   5000  FORMAT("I2E8G5E1E<I1")
0052   C
0053   C
0054   C=======================================
0063   C ENTER USER STATEMENTS FOR TEST HERE.
0064         DO 100 IJ=1,ILN
0065         READ(IDLU,*)A
0066   C USER STATEMENTS FOR TEST END HERE.
0067   C=======================================
0068   C
0069   100   CONTINUE
```

**Figure 3-13. Programming Code
for Free Field Input Performance**

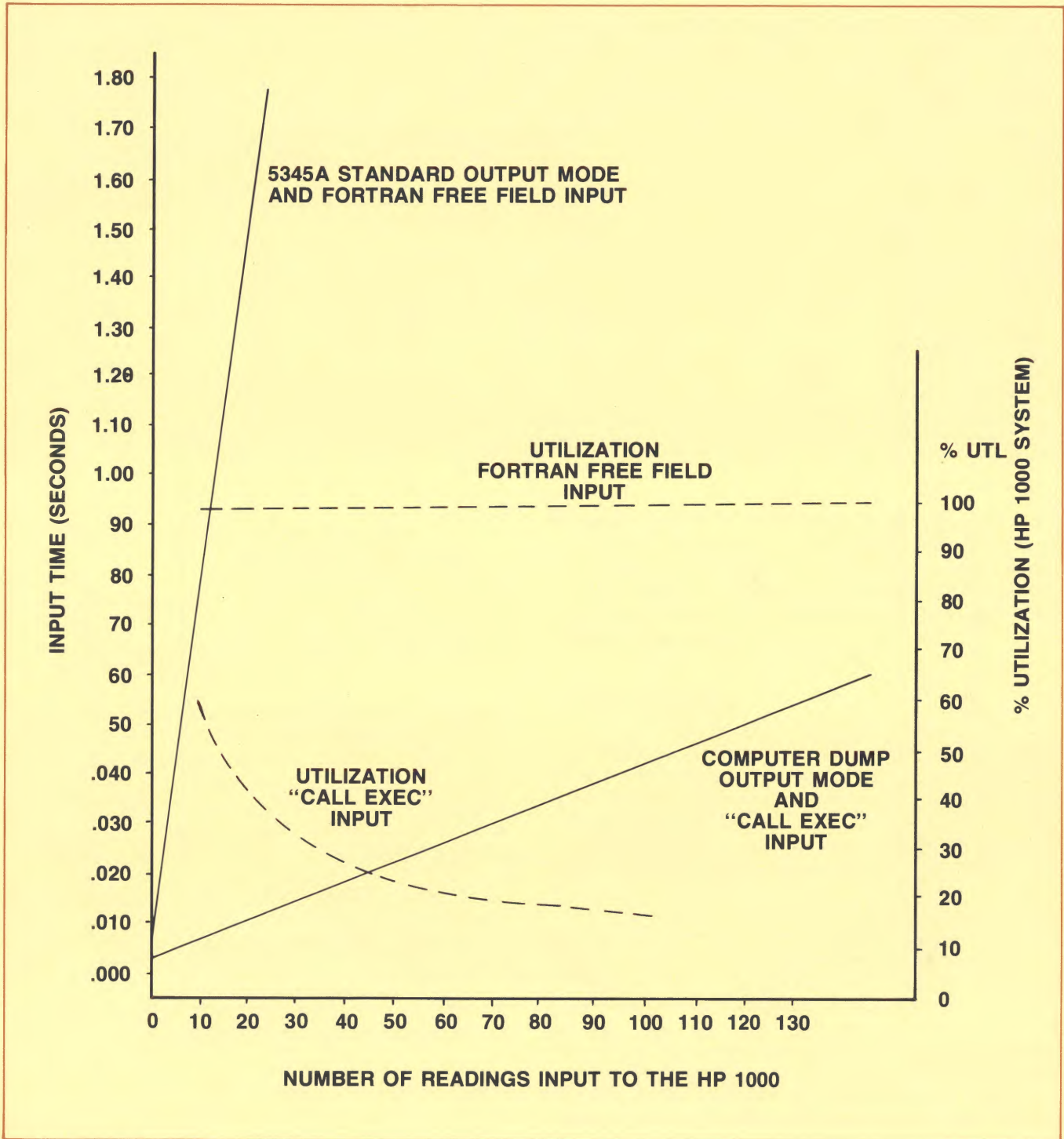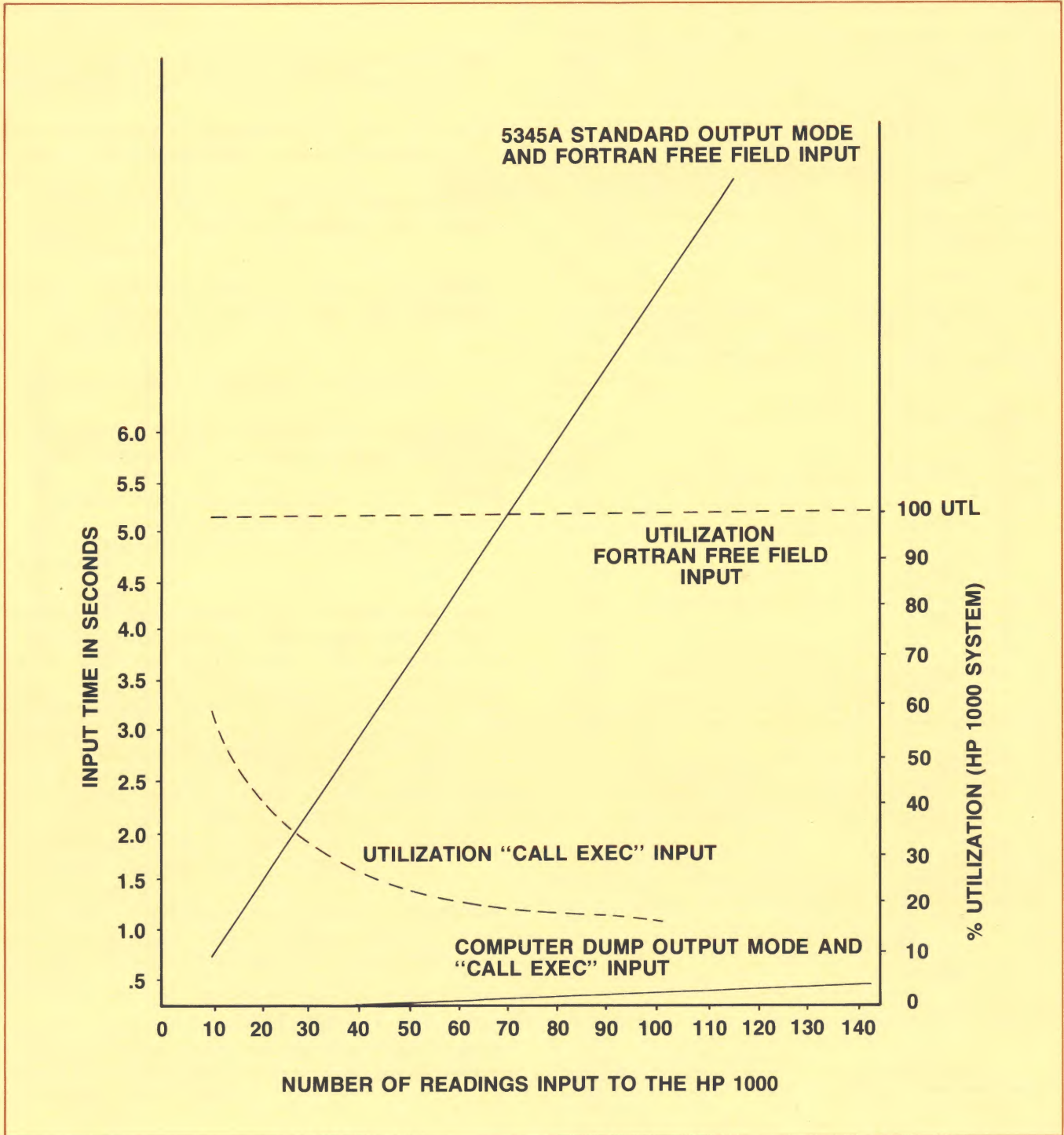[3]See "AN201-4, HP-IB Performance Measurements" for more information concerning DMA or non-DMA usage.

Figure 3-10. 5345A Performance Curves

Figure 3-12. 5345A Performance Curves