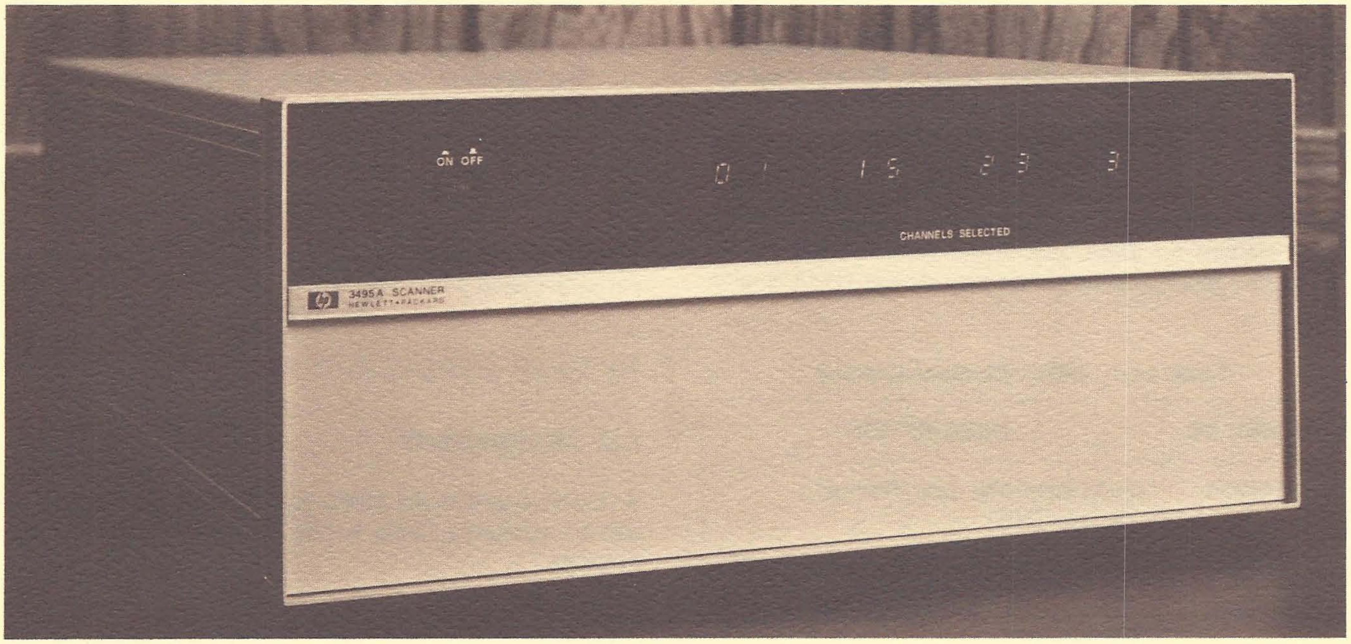
HP 3495A Scanner ⟷ HP-IB ⟷ HP 1000 Computer

Programming Guide

HEWLETT PACKARD

Application Note 401-11



Device Introduction

The 3495A Scanner is a versatile HP-IB instrument which will scan or provide contact closure control for up to 80 channels. Several boxes can be interconnected to provide 14 boxes with 80 channels per box or 1120 channels in all. Because of its specialized nature, several parts are assembled by the user to produce an instrument tailored to the application. The 3495A includes only the mainframe, power supply, and HP-IB hardware.

Two types of relays are available for use in the 3495A mainframe: low thermal relays for connection to low level sources such as thermocouples and strain gauges, and relay actuators for controlling higher current relays and distributing low current voltages (AC or DC).

Due to the multiplicity of options involved, this section can, at best, supplement the documentation offered in the 3495A Programming and Service Manual.[1] Actual setup and programming should not be started until this manual has been referenced.

[1] *Manual part number 03495-90012. See also Application Note 401-1 (5953-2800).*

The 3495A operation and performance is dependent both on hardware and software configuration. The early sections of the 3495A Programming and Service Manual should be studied carefully for successful 3495A HP-IB operation as coupled to the HP 1000.

The 3495A is designed for use exclusively with HP-IB. The scanner does not return measurements or internal status, and functions as a listener only. Several different channel options are available. Each allow random channel scanning, sequential channel scanning, or both modes.

The term "break-before-make" implies that simultaneous closures of scanner channels will not occur. Break-before-make switching (with partially sequenced closure) of 200 low thermal channels (option 001) may be assured in multiple scanners at each rear panel. The guard closes before low and high relays close. It opens after low and high relays open. Switching may also be done for 560 channels using HP 1000 software programming.

The actuator relays (option 002) have two sets of normally open contacts with four terminals per channel. Any number of channels may be closed simultaneously.

Thermocouple relays (option 003) are similiar to the low thermal relays (option 001) except that a thermocouple reference connector is substituted for the terminal connector. Nine temperature measurements can be made per assembly.

Other thermocouple relay options (options 004 and 005 which must be used with option 100) allow 20 voltage or 19 temperature measurements respectively, per assembly (see table 11-2). Channel 0 on each connector is reserved for a reference temperature monitoring resistor. Both of these options are capable of a switching speed up to 1000 channels per second when used as the only options in the 3495A Scanner. (See the "Performance" section.)

The 3495A may be used with the options listed in Table 11-1. Specifications for these options are shown in Table 11-2. Table 11-3 lists the documentation for various 3495A options.

Table 11-1. 3495A Channel Options

MODEL NO.	DESCRIPTION
44401A	Field Installable Low Thermal Decade (001)
44402A	Field Installable Actuator Decade (002)
44403A	Field Installable Thermocouple Decade (003)
44404A	Field Installable Low Thermal Duo-Decade (004)
44405A	Field Installable Thermocouple Decade (005)
44413A	Field Installable High-Speed Controller (100)
44095A	Service Kit
03495-84411	An additional Access Kit
10503A	BND-to-BNC cable (48") for Break-Before-Make

Addressing

Figure 11-1 depicts the 3495A, from above, with the top cover off. The location of boards A4 or A8 can be seen in the diagram. One or the other of these two boards are used depending on the options selected for the 3495A Scanner. The boards A4 or A8 contain the address switches used on the HP-IB.

An address must be selected for each 3495A by placing jumpers in the A4 address jack or by using the A8 dip switch (see figure 11-2). A closed switch is a logic "1", an open switch "0". A jumper in the jack is a logic "1", a jumper out, "0". The last two of the seven positions are ignored on the A4 assembly. On the A8 assembly, they are used for initializing the external increment capability (see "Programming") and implementing signature analysis tests (see the programming and service manual).

The address 11 octal is shown in Figure 11-2. This address is set at the factory.

System Preparations

LU Assignment

An LU is needed for the 3495A scanner on the HP-IB. The LU can be assigned using a File Manager command. For example,

```
:SYLU,30,10,11B
```

will be used if logical unit 30 on EQT 10 is to be assigned to one 3495A Scanner with address 11 octal.

Buffering

Although the HP 1000 buffering option may be used when programming 3495A channels, special care should be taken to see that measurement timing has been taken into account. Output buffering should not be allocated, however, until the scanner has been verified for correct operation. The File Manager command,

```
:SYEQ,10,UN
```

will unbuffer EQT 10.

[2]*The Bus Status and Configuration Utility is documented in Chapter 3 of AN 401-1 (part number 5953-2800).*

Table 11-2. 3495A Option Specifications

Option 001, Accessory 44401A 10 Channel Low Thermal Relay Assembly (Decade)

Type: Three pole, low thermal dry reed relays per channel. Third pole switches guard and is not low thermal. Break-before-make operation with partially sequenced closure: (Guard closes before low and high relays close. Guard opens after low and high relays open).

Maximum Contact Ratings:
- Voltage: 200 V peak
- Current: 200 mA (non-inductive)
- Power: 2 VA

Maximum Input Voltages:
- Between any two terminals: 230 V peak
- Guard to chassis: 200 V peak
- Guard to low: 200 V peak

Thermal Offset: < 2 μV differential EMF

Isolation: > 10^{10} Ω between high, low, guard

Switching Time: 10 msec maximum

Option 002, Accessory 44402A 10 Channel Relay Actuator Assembly (Decade)

Type: Two pole armature relay with two normally open contacts per relay. Single unswitched guard for 10 channels. Any combination of 10 channels may be closed or opened simultaneously.

Maximum Contact Ratings:
- Voltage: 100 V rms
- Current: 2 A rms
- Power: 200 VA

Maximum Input Voltage:
- Between any two terminals: 230 V peak
- Guard to chassis: 200 V peak
- Guard to low: 200 V peak

Thermal Offset: < 30 μV differential EMF

Switching Time: 40 msec maximum

CAUTION

For circuits fused at 2 amps or less and less than 200 VA capacity.

Option 003, Accessory 44403A 9 Channel Reference Junction Relay Assembly (Decade)

Type: Three pole, low thermal dry reed relays. Third pole switches guard and is not low thermal. Break-before-make operation with partially sequenced closure. (Guard closes before low and high relays close. Guard opens after low and high relays open.) Up to 9 channels of thermcouple connections. Remaining channel measures reference temperature.

Maximum Contact Ratings:
- Voltage: 42 V peak
- Current: 200 mA (non-inductive)
- Power: 2 VA

Maximum Input Voltage:
- Between any two terminals: 42 V peak
- Guard to chassis: 200 V peak

Thermal Offset (ambient temperature ± 1°C): < 2 μV differential EMF

Isolation: > 10^{7} Ω between high, low, guard

Switching Time: 10 msec maximum

Option 004, Accessory 44404A 20 Channel Low Thermal Relay Assembly

Type: Three pole, low thermal dry reed relays per channel. One pole is guard. Break before make.

Maximum Contact Ratings:
- Voltage: 42 V peak
- Current: 40 mA (non-inductive)
- Power: 1 VA

Maximum Input Voltages:
- Between any two terminals: 42 V peak
- Guard to chassis: 42 V peak

Thermal Offset (ambient temperature ± 1°C): < 1 μV differential EMF

Isolation: > 10^{7} Ω between high, low, guard

Switching Time: 1 msec maximum

Table 11-2. 3495A Option Specifications (Continued)

Option 005, Accessory 44405A Reference Junction Relay Assembly — 19 Channels

Type: Three pole, low thermal dry reed relays per channel. One pole is guard. Break-before-make. Up to 19 channels of thermocouple connections. Remaining channel measures reference temperature.

Maximum Contact Ratings:
Voltage: 42 V peak
Current: 40 mA (non-inductive)
Power: 1 VA

Maximum Input Voltages;
Between any two terminals: 42 V peak
Guard to chassis: 42 V peak

Thermal Offset (ambient temperature ± 1°C): < 1 μV differential EMF

Isolation: > 10^7 Ω between high, low, guard

Switching Time: 1 msec maximum

Option 100, Accessory 44413A High Speed Scanner Controller

Adds high speed capability to the 3495A. Used with Option 004 or 005 to provide a sequenced scan of up to 1000 channels/second for one 3495A. Synchronization is achieved with a trigger cable connection between the high speed scanner and a measuring instrument such as the Hewlett-Packard 3437A System Voltmeter.

AC Performance

	Opt. 001 10 Channel Low Thermal	Opt. 002 10 Channel Actuator	Opt. 004 20 Channel Low Thermal
High-to-Low Channel Capacitance Open: Closed:	 < 15 pF < 15 pF	 < 15 pF < 25 pF	 < 350 pF < 400 pF
Interchannel Capacitance	< 12 pF	< 12 pF	< 10 pF
Frequency Response (10 kHz reference, 50 Ω load)	Up to 100 kHz: ± 0.3 dB Up to 1 MHz: ± 0.5 dB	Up to 100 kHz: ± 0.3 dB Up to 1 MHz: ± 0.5 dB	Up to 1 MHz: ± 0.20 dB
Cross Talk Open Channel Termination 50 Ω 1 MΩ	 100 kHz 1 MHz < -70 dB < -50 dB < -33 dB < -30 dB	 100 kHz 1 MHz < -70 dB < -50 dB < -30 dB < -30 dB	 100 kHz 1 MHz < -70 dB < -50 dB < -50 dB < -50 dB

Temperature Performance — Option 003, 005, Accessories 44403A, 44405A Reference Junction Relay Assemblies

Thermistor Accuracy: ± 0.2°C

Temperature Gradient Along Terminals From Thermistor:
Steady State[1]: 0.1°C Maximum
Dynamic[2]: 0.3°C Maximum

Thermocouple Measurement Accuracy: The following graphs represent performance for various types of thermocouples under steady state and dynamic conditions. The accuracy includes such errors as thermistor accuracy, temperature gradients, thermal offset, thermistor curve fit accuracy and thermistor lead resistance.

[1] Applies to ambient temperature ± 1°C deviations
[2] Applies to ambient temperature step of 5°C or 5°C/hour maximum rate of change

Figure 11-1. 3495A Printed Circuit Layout

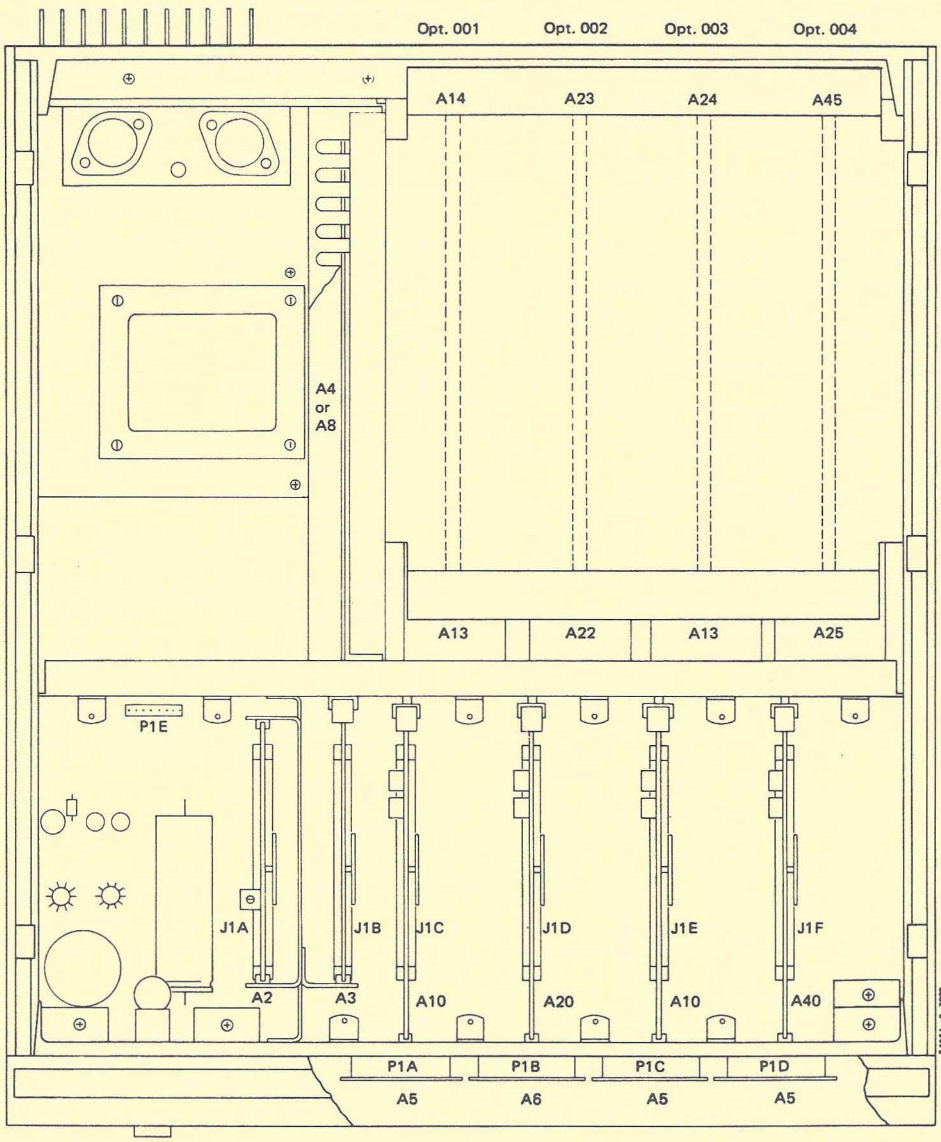


Table 11-3. 3495A Option Documentation

DOCUMENT	DESCRIPTION
44401-90000	Operating Note for HP 3495A Options 001,002 & Accessories 44401A, 44402A
44403-90002	Operating Note for HP 3495A Option 003 & Accessory 44403A
44404-90000	Operating Note for HP 3495A Option 004 & Accessory 44404A
44405-90000	Operating Note for HP 3495A Option 005 & Accessory 44405A
44413-90000	Operating Note for HP 3495A Option 100 & Accessory 44413A
44095-90002	Operating Note for HP 3495A Service Kit 44095A/B
44195-90000	Operating Note for HP 3495A Test Kit 44195A
P-03495-64103-1B	Part Note for HP 3495A Reference Junction Connector 03495-64103 supplied with Option 003

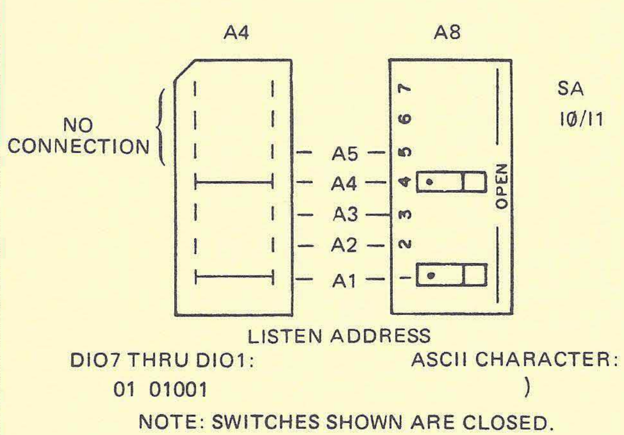


Figure 11-2. 3495A Address Switches or Jumpers

Time-Out

A time-out value should be specified for the bus. The time-out indicates an error when used with the 3495A. This will indicate a hardware or software malfunction. The time-out value should be set larger than the maximum amount of time required for the 3495A to select a channel or series of channels under program control.

From File Manager,

```
:SYTO,10,100
```

will set the time-out for EQT 10 to 1 second.

Configuration

Except for user program error processing, the device configuration word will default to the correct setting. From File Manager,

```
:CN,30,25B,17400B
```

will allocate set up user program error processing for LU 30. In FORTRAN,

```
CALL CNFG(30,1,17400B)
```

will perform an identical operation. The BSCU[2] may be used to check 3495A configuration.

Remote

The 3495A need not be in remote for successful operation.

Programming

Details of 3495A programming are dependent on the particular channel option chosen for the application. This involves, both hardware programming and software programming.

Hardware programming (i.e., setting switches and moving jumpers) is documented in the 3495A Programming and Operating Manual and must be carefully accomplished before the software steps are begun. The hardware programming section in the 3495A manual should be read before continuing in this section.

Table 11-4. 3495A Programming Commands

(Shaded instructions are valid with Option 100 only.)

INSTRUCTION	ASCII CHARACTER	DECIMAL
Digit	0,1,2,3,4,5,6,7,8,9	48 thru 57
Space	SP	32
Clear	C	67
Execute	Carriage Return (CR), E	13, 69
External Increment Off	10	73. . .48
External Increment On	11	73. . .49
First Channel	F	70
Last Channel	L	76
Software Increment	S	83
No Operator	NUL, DEL	0, 127
Delimiter	Any other character	1 thru 126*

*See the programming and operating manual.

Table 11-4 summarizes the ASCII programming codes recognized by the 3495A. Program execution is triggered by a carriage return, linefeed (CRLF) or the character "E". When option 100 is being used in the 3495A, the character "S" causes accumulated instructions to be executed.

Section 3 of the 3495A Programming and Operating Manual supplies a complete description of the various programming formats available for the 3495A. This section should be read carefully during the programming phase.

The 3495A can be easily verified for proper operation from File Manager or FORTRAN. From File Manager, set the list device to the 3495A logical unit to be tested. The command,

```
:LL,30
```

sets the list device to LU 30. If the 10 channel relay actuator assembly is installed (option 002) and the scanner has been hardware programmed to close channels 00-09, the statement,

```
:AN,C000102030405
```

will close the first five channels and show visually that these channels are working. The channels may be cleared by sending,

```
:AN,C
```

These channels should be closed separately and a signal should be applied (and measured) to each one for a thorough verification check.

If option 001 is installed, only one channel may be closed at a time, and visual operation may be verified by incrementing the channels. Assuming channels 11-19 have been hardware programmed to close, the statements,

```
:AN,C11
:AN,C12
:AN,C13
:AN,C14
:AN,C15
```

will increment through channels 11,12,13,14, and 15.

If options 004 or 005 are installed, only one channel may be closed at a time. The File Manager string,

```
:AN,F00L0900SS
```

will decrement from channel 09 to channel 00.

When using the scanner, it is important to realize that in some cases channels may be selected by the computer at a faster rate than that allowed by 3495A specifications. Because the 3495A accepts the programming commands and does not return completion status, the rate must be limited using HP 1000 software or an external triggering device.

The FORTRAN statement,

```
CALL EXEC(12,0,IRES,0,-IOFST)
```

will act as a programmable software delay to limit the switching rate by IRES and IOFST.[3]

The standard "CALL EXEC(12)" subroutine provides delays from 10 milliseconds to about 9 hours. When more time is needed, a subroutine similiar to "WAIT" shown in figure 11-3 can be used. This routine provides a full range of delays from 10 milliseconds out to about 3 E+31 years. The parameter supplied to WAIT is a real value and in seconds.

Figure 11-4 shows a FORTRAN program which can be used to increment channels. Option 002 is used for channels 00-09, and option 001 is used for channels 10-19.

Many types of programming formats may be used with the 3495A. These are discussed for each option in the 3495A Programming and Operating manual. The scanner can be sequentially or randomly programmed from HP 1000 software, or an initial setup may be performed. Then the 3495A can be scanned using an external trigger signal.

HP 1000/3495A example programming sequences can be found in the next section, along with their respective performance evaluations.

[3] *See the RTE Programmers Reference Manual (for RTE-IV, part number 92067-90001).*

```
FTN4,L
C
      SUBROUTINE WAIT(RSEC),03-14-79 (GWG) WAIT (INCLUDING DAYS)
      SEC=RSEC
    5 IF(SEC.LT..005)RETURN
      IF(SEC.GT..99) GO TO 10
      IRES=1
      ISEC=SEC100.
      CALL EXEC(12,0,IRES,0,-ISEC)
      RETURN
   10 IF(SEC.GT.3599.99)GO TO 20
      IRES=2
      ISEC=SEC
      SEC=SEC-ISEC
      CALL EXEC(12,0,IRES,0,-ISEC)
C SUBTRACT .005 SEC FOR THE EXEC(12)
      SEC=SEC-.005
      GO TO 5
   20 IF(SEC.GT. 32399.99)GO TO 30
      IHR=SEC/3600.
      IRES=3
      SEC=SEC-IHR3600.
      CALL EXEC(12,0,IRES,0,-IHR)
C SUBTRACT .005 SEC FOR THE EXEC(12)
      SEC=SEC-.005
      GO TO 5
   30 ISCD=SEC/32400.
      IRES=3
      SEC=SEC-(ISCD32400.)
C 9 HOUR WAITING PERIODS
   40 CALL EXEC(12,0,IRES,0,-9)
      ISCD=ISCD-1
C SUBTRACT .005 SEC FOR THE EXEC(12)
      SEC=SEC-.005
      IF(ISCD.NE.0)GO TO 40
      GO TO 5
      END
      END$
```

Figure 11-3. A Wait Subroutine in FORTRAN

```
FTN4,L
      PROGRAM A3495(3),01-27-79 (GWG) 3495A FORMATS
      COMMON ILU,ILST,IDLU
      DATA NO/2HNO/
      IF(INPRM(ID).EQ.NO) GO TO 999
      DO 20 IT=0,1
      DO 20 IO=0,9
   20 WRITE(IDLU,10)IT,IO
   10 FORMAT("C"2I1)
      STOP
  999 WRITE(ILU,30)
   30 FORMAT(" :RU,A3495,ILST,IDLU"/)
      END
```

These statements select channels 00 through 19.

Figure 11-4. FORTRAN Program to Increment Channels

Performance

Four different performance evaluations were conducted with the 3495A. In these tests the main criteria was speed. Using the high-speed scanner controller (option 100) and reference junction relay assembly (option 005), measurements were conducted to determine speed performance and average system utilization during a task.[4]

Channel Selection Using Standard Software

Measurements were conducted for the HP 1000 and the 3495A alone. Twenty channels were selected consecutively by sending the character "S" from the HP 1000 to trigger accumulated instructions. For example, if 100 channels were selected in all, the 20-channel assembly would be repeated 5 times. Because option 005 scans at a maximum rate of 1000 channels per second (1 millisecond per channel), an RTE "EXEC" request was used to limit 3495A switching speed to that dictated by 3495A specifications. The minimum resolution of an RTE request of this type is 10 milliseconds so the 3495A's effective switching rate was 100 channels per second (after the initial setup period). This is only a factor for option 005 and when the scanner is being triggered by the user's program. Other options require up to 40 milliseconds per channel settling time. The graphical performance data can be found in figure 11-5. The program statements are shown in figure 11-6.

[4] *The "task" concept is defined in Application Note 401-1 (part number 5953-2800), chapters 4 and 5.*

Channel Selection Using External Trigger and BCD Input

Measurements were conducted with the HP 1000, the HP 3495A and the HP 3437A digital voltmeter. The 3437A/3495A combination allows the scanner to be triggered externally (by the 3437A). For example, the HP 1000 requests 20 readings from the 3437A. The 3495A will then be triggered by the 3437A 20 times automatically. If 100 readings are requested in all, the 20-channel assembly will be repeated 5 times.

Due to the 1000 reading-per-second limitation of the 3495A, this evaluation was set up to obtain measurements from the 3437A at 1 millisecond intervals.

Initially, the 3495A was programmed for a first channel of 20, a last channel of 39, and external triggering (shown in line 53, figure 11-7). The 3437A was programmed for internal trigger at 1 millisecond intervals (T1 D.001S) and BCD output format (F2), meaning that two bytes are returned per reading rather than the seven conventional ASCII bytes.

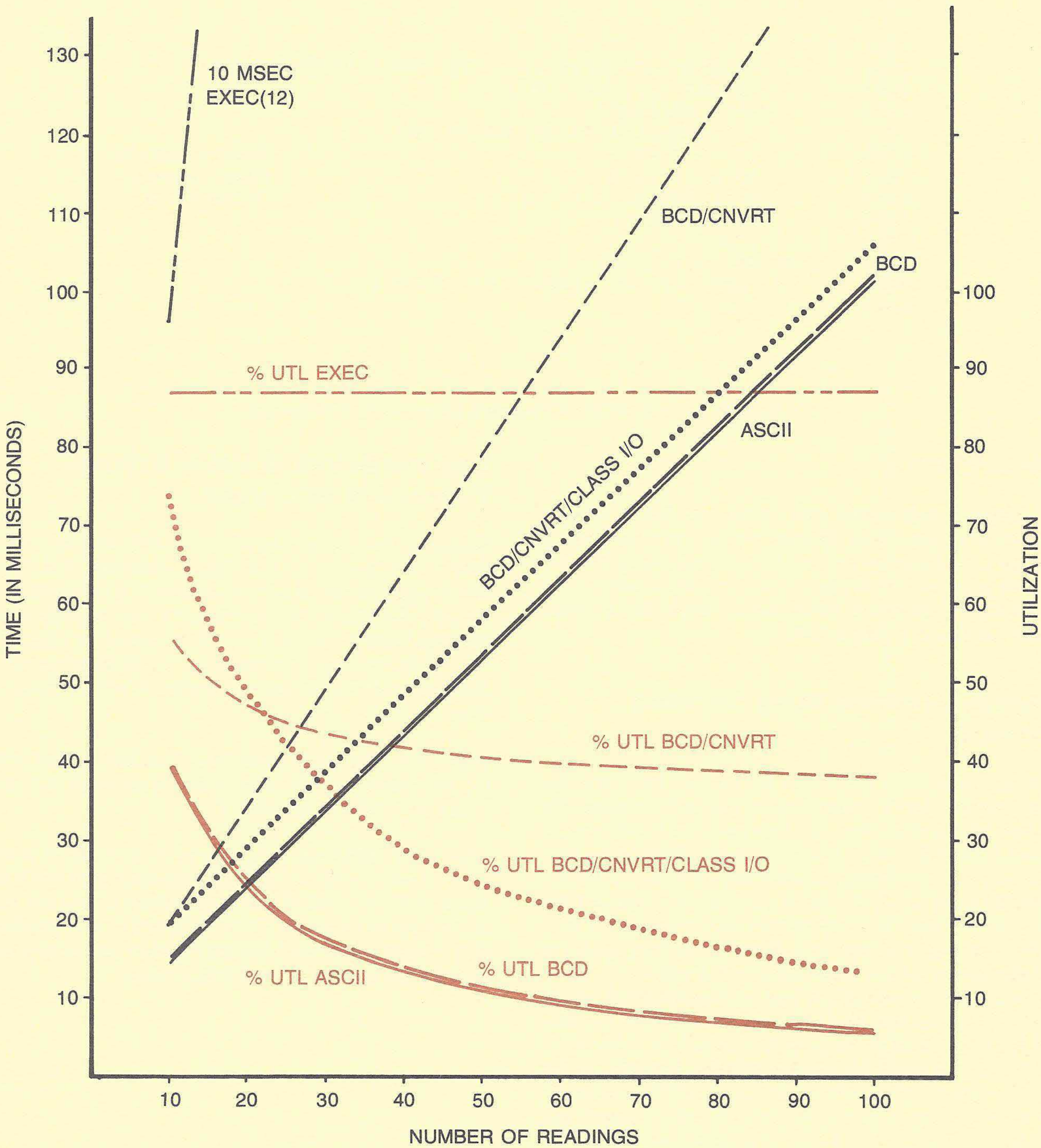


Figure 11-5. Graphical Data for 3495A/3437A/HP 1000 Performance

```
C=====================================================
C ENTER USER STATEMENTS OUT OF TEST HERE.
C
      IBUF(1)=2HS
      WRITE(IDL1,1111)
 1111 FORMAT("CL39F20I0")
C     WRITE(IDL2,1112)ILN
C1112 FORMAT("F2 N"I6"S D.01S T1")
C
C
C=======================================================

C=========================================================
C ENTER USER STATEMENTS FOR TEST HERE.
      DO 100 IJ=1,ILN
      REG=EXEC(2,IDL1,IBUF,-1)
      CALL EXEC(12,0,1,0,-1)
C USER STATEMENTS FOR TEST END HERE.
C========================================================
```

Figure 11-6. Channel Selection Using Standard Software

```
C=====================================================
C ENTER USER STATEMENTS OUT OF TEST HERE.
C
      IL=ILN2
      WRITE(IDL1,1111)
 1111 FORMAT("CL39F20I1")
      WRITE(IDL2,1112)ILN
 1112 FORMAT("F2 N"I6"S D.001S T1")
C
C
C=======================================================

C=========================================================
C ENTER USER STATEMENTS FOR TEST HERE.
C     DO 100 IJ=1,ILN
      REG=EXEC(1,IDL2+100B,IBUF,-IL)
C USER STATEMENTS FOR TEST END HERE.
C========================================================
```

Figure 11-7. 3437A/3495A BCD Input

```
C=====================================================
C ENTER USER STATEMENTS OUT OF TEST HERE.
C
        IL=ILN2
        WRITE(IDL1,1111)
 1111 FORMAT("CL39F20I1")
        WRITE(IDL2,1112)ILN
 1112 FORMAT("F2 N"I6"S D.001S T1")
C
C
C=======================================================

C=========================================================
C ENTER USER STATEMENTS FOR TEST HERE.
C       DO 100 IJ=1,ILN
        REG=EXEC(1,IDL2+100B,IBUF,-IL)
        IF(CNVRT(IBUF,IB,OBUF).LT.0)STOP 1
C USER STATEMENTS FOR TEST END HERE.
C========================================================
```

Figure 11-8. 3495A/3437A Performance, BCD Input With Conversion

The HP 3437A allows the user to vary the number of readings returned between end-of-record terminators. This is programmed by sending an "N", then the number of readings to be taken, and "S". The number of readings was varied to produce the performance curves shown in figure 11-5. Note that only one HP 1000 input request was made to obtain the readings. This means that the overhead required to initiate the I/O operation is incurred only once. See figure 11-7 for the actual program statements used for the measurements.

Channel Selection Using External Trigger and BCD Input With Conversion

These measurements are identical to those described above, but the conversion subroutine developed in the HP 1000/3437A Programming Guide (Application Note 401-10, part number 5953-2809) was used to convert the readings to HP 1000 binary. A significant time and utilization increase can be seen because all of the readings are first input, then processed. (See figure 11-8 for the program statements.)

Channel Selection Using External Trigger and ASCII Input

These measurements were conducted as those for binary input with the 3495A, 3437A and the HP 1000. The number of readings between end-of-record terminators was programmed the same as above, but the length of the ASCII input request (to the HP 1000) was multiplied by 7. This value accommodates the ASCII input length generated by each reading in the 3437A (see figure 11-9).

Channel Selection Using External Trigger, BCD Input with Conversion, and Class I/O

These measurements are identical to the BCD measurements with conversion already described. However, an attempt was made to interleave conversion processing with input processing. For example, instead of performing one input request for 100 readings, two special requests were made for 50 readings each. Class I/O[3] allows the user to make an input request and then continue with the program before the request has completed. Essentially, the user program waits for the first 50 readings, then processes these values while the next 50 readings are being input. This method improved input with conversion dramatically as shown in figure 11-5. The programming code is shown in figure 11-10.

```
C=========================================================
C ENTER USER STATEMENTS OUT OF TEST HERE.
C
      IL=ILN*7
      WRITE(IDL1,1111)
 1111 FORMAT("CL39F20I1")
      WRITE(IDL2,1112)ILN
 1112 FORMAT("F2 N"I6"S D.001S T1")
C
C
C==========================================================


C=============================================================
C ENTER USER STATEMENTS FOR TEST HERE.
C     DO 100 IJ=1,ILN
      REG=EXEC(1,IDL2,IBUF,-IL)
C USER STATEMENTS FOR TEST END HERE.
C============================================================
```

Figure 11-9. External Trigger and ASCII Input

```
C=========================================================
C ENTER USER STATEMENTS OUT OF TEST HERE.
C
      WRITE(IDL1,1111)
 1111 FORMAT("CL39F20I1")
      IHF=ILN/2
      WRITE(IDL2,1112)IHF
 1112 FORMAT("F2 N"I6"S T1")
C
C
C==========================================================


C=============================================================
C ENTER USER STATEMENTS FOR TEST HERE.
C     DO 100 IJ=1,ILN
      IC1=0
      IC2=0
C     IHF=ILN/2
C     IOTH=IHF+MOD(IHF,2)
C BCD/BINARY CLASS READ REQUESTS
      REG = EXEC(17,IDL2+100B,IBUF1,IHF,IDUM1,IDUM2,IC1)
      REG2= EXEC(17,IDL2+100B,IBUF2,IHF,IDUM1,IDUM2,IC2)
C CLASS  INPUT FIRST BUFFER
      CALL EXEC(21,IC1,IBUF1,IB)
C CONVERSION OF FIRST BUFFER
      IF(CNVRT(IBUF1,IB/2,OBUF1).LT.0)STOP 1
      CALL EXEC(21,IC2,IBUF2,IB2)
      IF(CNVRT(IBUF2,IB2/2,OBUF2).LT.0)STOP 2
C USER STATEMENTS FOR TEST END HERE.
C============================================================
```

Figure 11-10. Class I/O Input Performance Code.

General Performance Considerations

High speed transfers were executed using DMA in all cases. When measurements with delay times less than 10 milliseconds are being taken, DMA is suggested for the 3437A DVM.

In some situations it was found that 3437A measurements were lost when delay times were less than 1.5 milliseconds. This occurs when the 3437A triggers the next 3495A channel before the last reading has been taken by the HP 1000. The next channel is selected, but the previous reading is in the 3437A output buffer. Channel sequencing and control is lost. This can happen due to overhead generated by other user programs executing while the I/O operation is taking place. Care should be taken to insure that high performance operations are "dedicated" by setting the proper program priorities.

The "ignore trigger" error condition can be detected by recognizing the "trigger ignore" flag within the 3437A. One way is to set up a high priority SRQ program to be scheduled when the SRQ condition occurs.[5] This user program can be set up to output a message to the user's terminal.

Another problem which causes the "trigger ignore" situation is making an input request of an improper length. All programs shown here assume buffer lengths in characters (bytes, having a negative sign). The buffer length must be accurate for proper results.

The differences in the graphical data in figure 11-5 are subtle but significant. It can be seen that BCD input with conversion utilized the system more and also takes longer than just BCD input with no conversion. This discrepancy has to do with the method which was used for input and conversion. The operations were sequential. First, all of the data was input to memory, then conversion was begun.

Notice that the payoff for coding 3437A measurements in 2 byte BCD as opposed to receiving 7 bytes of ASCII is graphically insignificant. The data owes this to the fact that the incremental transfer time per byte (via DMA) is small in comparison to the delay time per measurement. The payoff is evident when measurements need not be converted into binary for processing — for example, when this data will be displayed on an ASCII peripheral. The graph shows that ASCII input should be used for this application.

DMA I/O is a statistical process. That is, in some cases, another program may be executing at the same time I/O is in progress. This is evident in the two similiar utilization curves for BCD and ASCII. Note, however, that utilization is heavily dependent on the nature of the programs resident and executing in the system.

The tabular data for the five different types of measurements is shown in table 11-5. Utilization values can be found there also.

[5] *See Application Note 401-10, HP 3437A/HP 1000 Programming Guide (5953-2809), for complete details about detecting "trigger ignore" in the 3437A.*

Table 11-5. Performance Measurements

INPUT/TRIGGER	NO. OF READINGS	PERFORMANCE TIME (IN SECONDS)	UTILIZATION
Standard Software (figure 11-6)	10	.096	86.48%
	20	.194	86.61%
	30	.291	86.65%
	40	.387	86.71%
	50	.484	86.74%
	60	.581	86.74%
	70	.678	86.75%
	80	.775	86.76%
	90	.922	87.24%
BCD Input (figure 11-7)	10	.015	39.08%
	20	.024	23.55%
	30	.034	16.86%
	40	.044	13.11%
	50	.053	10.74%
	60	.063	9.11%
	70	.073	7.91%
	80	.082	6.98%
	90	.092	6.25%
	100	.102	5.66%
BCD with Conversion (figure 11-8)	10	.020	55.31%
	20	.035	46.76%
	30	.050	43.35%
	40	.065	41.51%
	50	.080	40.36%
	60	.095	39.57%
	70	.110	39.00%
	80	.125	38.56%
	90	.140	38.22%
	100	.155	37.94%
ASCII Input (figure 11-9)	10	.015	39.17%
	20	.025	23.82%
	30	.034	17.11%
	40	.044	13.41%
	50	.054	11.01%
	60	.063	9.37%
	70	.073	8.15%
	80	.083	7.22%
	90	.092	6.49%
	100	.102	5.90%
Class I/O (figure 11-10)	10	.020	74.70%
	20	.030	49.82%
	30	.039	37.46%
	40	.048	29.90%
	50	.058	24.94%
	60	.068	21.38%
	70	.077	18.72%
	80	.087	16.64%
	90	.097	14.98%
	100	.107	13.62%

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