HP 3455A Digital Voltmeter

◄ HP-IB ►

HP 1000 Computer

Programming Guide

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Device Introduction

The model 3455A Digital Voltmeter makes AC voltage measurements with five-digit resolution and DC voltage and resistence measurements with five- or six-digit resolution as programmed by the user. The 3455A employs an automatic calibration (Auto Cal) feature which automatically corrects for possible gain and offset errors in the analog circuitry to provide maximum accuracy. A removable reference module permits external calibration of the DC voltage and resistance functions. The reference module can be removed, calibrated, and returned to the instrument; or the module can be replaced with another recently calibrated reference. A MATH feature permits voltage or resistance measurements to be scaled into convenient units or to be read directly in percent error from a selected reference.

The 3455A is HP-IB programmable for system applications. [1] Programming is made simple due to the ingenious design of the front panel which allows the programmer to see visually which multimeter functions must be selected. The 3455A is both a talker and a listener on the bus. Typically, the instrument is programmed, externally triggered, and then the measurement is read into the computer.

Addressing

The 3455A has a set of binary address switches on the rear panel which allows the operator an easy method of selection. The 5 bit octal address 26 is often used as the 3455A talk/listen address (figure 7-1).

A5	A4	A3	A2	A1	
1	0	1	1	0	Binary
2				6	Octal

Figure 7-1. Binary and Octal Address Representation

System Preparations

LU Assignment

One logical unit number (LU) should be assigned to the 3455A. After setting the switches as shown in figure 7-1, assign a logical unit number. From File Manager,

    :SYLU,15,10,26B

would assign LU 15 to equipment table 10. The device address associated with LU 15 would be 26 octal.

Buffering

The buffering option for the 3455A EQT should be turned off until the device has been checked out.

    :SYEQ,10,UN

would set the equipment table in the above example to the unbuffered mode.

Remember, the bus must be unbuffered if the user program performs its own error checking.

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[1]See the Operating and Service Manual for the 3455A (part number 03455-90002) and Application Note 401-1 (5953-2800).

Time-out

The time-out value for the EQT should be given consideration for the 3455A. Remember that the time-out value will affect all devices on the same EQT, and should encompass the needs of all these devices.

From File Manager, a system request may be used to set the time-out value.

      :SYTO,10,100

will set the time-out on EQT 10 to one second.

A 3455A time-out is usually considered to be an error condition. By default this error will be detected by the operating system; however, the user program may handle the situation by setting up the device configuration word accordingly.

When bit eight (the E bit) of the configuration word is zero, the operating system will set the logical unit down and put the user program into the general wait state until the "UP" operator request is entered from a user terminal. When the E bit is configured to one, the time-out will not stop execution of the user program. Instead the current bus status should be checked (by calling the subroutine "IBERR") each time an I/O request is made to determine whether the time-out occurred.

Two examples of the device configuration word are shown (figure 7-2), one for operating system processing of the time-out condition and the other for user program processing of the error.

A File Manager request may be used to adjust the error bit in the device configuration word. If the LU to be configured is 15,

      :CN,15,25B,17400B

declares that time-out processing will be performed by the user program. Other bits also have specific meanings as described in the "Configuration" section.

Configuration

The device configuration word should be examined for possible changes to the default mode.

The 3455A may be programmed to assert the SRQ line when a reading is ready to be sent back to the computer. The S bit should be turned off in this situation.

      :CN,15,25B,17000B

for LU 15 represents the default condition of the device configuration word.

```
            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
            -------------------------------------------------

     E=0   HP-IB ERRORS WILL ABORT THE PROGRAM.


            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  1  0  0  0  0  0  0  0  0
            -------------------------------------------------
             0        1        7        4        0        0
            -------------------------------------------------

     E=1   USER PROGRAM WILL HANDLE HP-IB ERRORS.
```
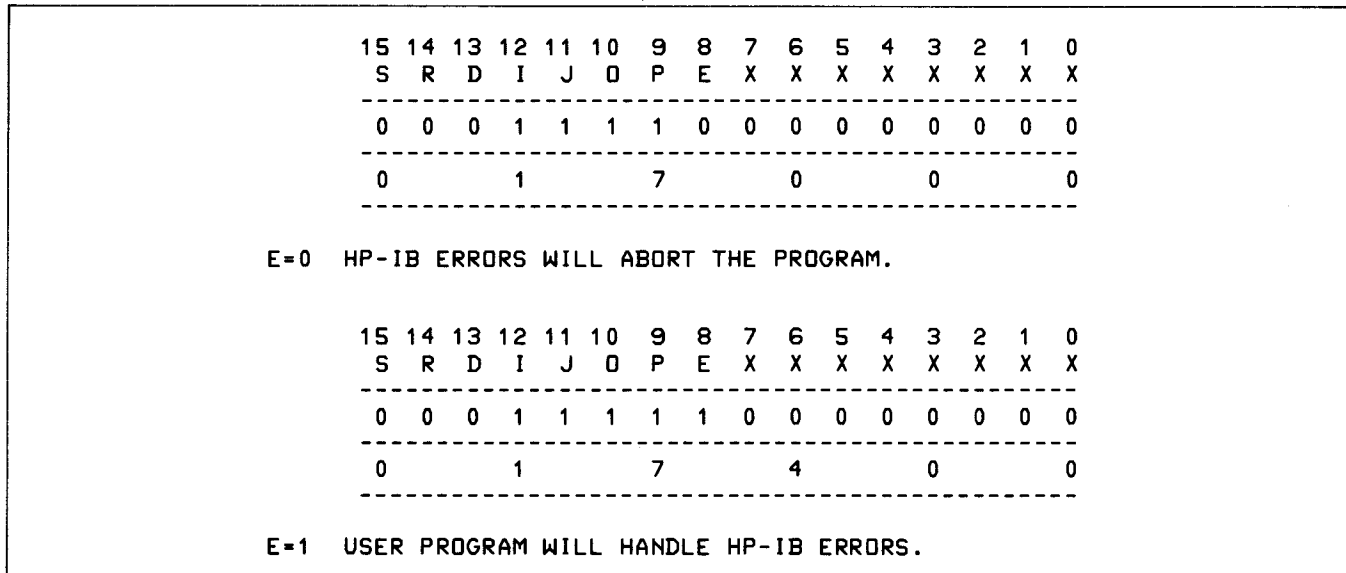
Figure 7-2. Example Device Configuration Words

DMA is not usually allocated for the 3455A. Typically, the two DMA channels in RTE are used for the faster devices in the system like tape drives and magnetic discs. Because the 3455A is a slower device which transmits short records, it can tie up a DMA channel for long periods of time. (See 3455A performance characteristics.) Set bit 13 (the "D" bit) to zero in the device configuration word.

The S,I,J,O, and P bits all default to the correct value of one.

The following example demonstrates a typical configuration request from file manager:

> :CN,15,25B,17000B

for LU 15. See figure 7-3 for a description of each bit.

Remote

The 3455A must be set to remote operation before programming can begin. Remote is one of the HP-IB management lines, and once asserted, it will remain in that state until it is cleared. The remote enable command may be accomplished from File Manager (in the WELCOM file at boot-up for example),

> :CN,15,16B

for LU 15, or from the user FORTRAN program,

> CALL RMOTE(15)

An example File Manager procedure file is shown in figure 7-4.

```
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 7-3. Configuration Evaluation

```
:SYLU,15,10,26B      Assign the logical unit number.
:CN,15,16B           Set the 3455A to remote.

:CN,15,25B,17400B    User program will handle errors.
:SYEQ,10,UN          Unbuffered operation.
```

Figure 7-4. An Example File Manager Procedure File

Programming

When the basic idea concerning the measurement operation of the 3455A is understood, the digital voltmeter can be programmed simply by examining its front panel. No manuals or tables are needed. (These programming functions are shown in table 7-1.)

Table 7-1. HP-IB Program Codes

	Control	Program Code
FUNCTION	DC Volts AC Volts Fast AC Volts 2 Wire kΩ 4 Wire kΩ Test	F1 F2 F3 F4 F5 F6
RANGE	.1 1 10 100 1 K 10 K AUTO	R1 R2 R3 R4 R5 R6 R7
TRIGGER	Internal External Hold/Manual	T1 T2 T3
MATH	Scale Error Off	M1 M2 M3
ENTER	Y Z	EY EZ
STORE	Y Z	SY SZ
AUTO CAL	Off On	AØ A1
HIGH RESOLUTION	Off On	HØ H1
DATA READY RQS	Off On	DØ D1
BINARY PROGRAM		B

Three steps are required:

a. Program the front panel instrument controls (DC volts, range .1 volts, trigger mode hold manual, etc.). The first letter of each word (on the front panel) describing a logical group of buttons on the device is underlined.

To "push a button" under software control, the first letter of the logical group is sent, followed by the number representing the position of the button in that group. There are no delimeters between commands. For example, "F2R7" sets AC volts and autorange.

b. Trigger the 3455A to take a measurement. Trigger mode T1 (internal trigger) should not be used for bus operations to ensure the proper reading is taken. Instead, trigger mode "T3T3" should be used.

c. Measurements may also be taken by alternately performing the trigger request, CALL TRIGR (IDLU), and then performing a read request with a variable name to return the measurement to the computer.

The example program (figure 7-5) shows one method of 3455A programming. After the first reading is taken, a trigger command can be used for each successive reading.

The following program in figure 7-6 can be used to make 50 readings and average the result.

To speed up readings, AUTO CAL may be turned off. This is done by sending "A0":

        WRITE (15,10)
    10 FORMAT ("A0")

for LU 15. "A1" turns auto calibrate back on.

The 3455A also has what is called "learn mode". This allows the front panel switch positions to be learned by the computer so that the same setup can be repeated later. This is done by sending "B" for binary program (figure 7-7).

```
0001   FTN4,L
0002        PROGRAM A3455(3),07-21-78 (GWG) 3455A MEASUREMENTS
0003        REAL          MEAS(10)
0004        INTEGER       YES
0005        COMMON        ILU,ILST,IDLU
0006        DATA          YES/2HYE/
0007        IF(INPRM(ID).EQ.YES)GO TO 10        Obtain input parameters.
0008        WRITE(ILU,20)                        If these are not available, instruct how
                                                 to run the program then exit.
0009     20 FORMAT(":RU,A3455,ILST,IDLU")
0010        STOP
0011     10 WRITE (IDLU,30)                      Program the DVM.
0012     30 FORMAT ("F1R7T2T3")
0013        IF (IBERR(IDLU).NE.0)GO TO 100       Check for errors.
0014        DO 40 J=1,10
0015        CALL TRIGR (IDLU)                    Trigger the DVM.
0016        READ (IDLU,*) MEAS(J)                Read the measurement. Free field
                                                 input can be used.
0017        IF(IBERR(IDLU).NE.0)GO TO 100        Check for errors.
0018     40 CONTINUE
0019        WRITE(ILU,50)   (MEAS(J),J=1,10)     After 10 measurements are taken, print
                                                 them on the user's terminal.
0020     50 FORMAT (5(1X,E13.6))
0021    100 END
```

Figure 7-5. FORTRAN Program to Obtain 3455A Measurements

```
0001   FTN4,L
0002        PROGRAM B3455(3),07-21-78 (GWG) AVERAGE 50 READINGS
0003        REAL          MEAS(50)
0004        INTEGER       YES
0005        COMMON        ILU,ILST,IDLU
0006        DATA          AVG/0./,YES/2HYE/
0007        IF(INPRM(ID).EQ.YES) GO TO 10        Obtain input parameters.
0008        WRITE (ILU,20)
0009     20 FORMAT (" :RU,B3455,ILST,IDLU")
0010        STOP
0011     10 WRITE (IDLU,30)                       Program the 3455A.
0012     30 FORMAT ("F1R7T2T3")
0013        DO 40 I = 1,50                        Obtain 50 measurements.
0014        CALL TRIGR (IDLU)                     Trigger each one.
0015        READ (IDLU,*) MEAS (I)                Free field input.
0016     40 AVG = AVG + MEAS (I)                  Sum up the measurements.
0017        AVG = AVG/50.                         Compute the average.
0018        WRITE (ILU,50) AVG
0019     50 FORMAT ("AVERAGE:"E13.6)
0020        END
```

Figure 7-6. FORTRAN Averaging Program for the 3455A

```
0001    FTN4,L
0002          PROGRAM LEARN (3),07-21-78 (GWG) BINARY LEARN
0003          INTEGER        IPM(5), ILRN(2)
0004          COMMON         ILU,ILST,IDLU
0005          DATA           NO/2HNO/
0006          IF(INPRM(ID).EQ.NO)GO TO 100
0007          WRITE (IDLU,10)
0008       10 FORMAT("B")
0009          READ (IDLU,20)(ILRN(I),I = 1,2)
0010       20 FORMAT (2A2)
0011          PAUSE
0012          WRITE(IDLU,30)ILRN
0013       30 FORMAT("B",A2)
0014      100 END
```

Figure 7-7. 3455A Learn Mode Program

Service Requests

If manual or external triggering is used, the time interval between readings may be so long that the computer may be wasting time waiting for a reading. The digital voltmeter can "interrupt" the computer when a reading is completed and have the computer take the reading. This is called "Data Ready Request Service." To use this feature, the command "D1" is given to the 3455A. The program in figure 7-8 demonstrates this capability.

Take a situation where the 3455A is triggered externally and measurements may come every week, month, i.e., very long periods of time. Assuming that the operating system remains intact during this period, and the ID segment of the program to be scheduled remains in memory, then the user program can be isolated from the system on a mass storage disc until an SRQ arrives from the 3455A. When the SRQ is generated, the HP-IB driver automatically performs a serial poll to determine which device generated the SRQ, and then schedules the associated program. [2]

```
FTN4,L
       PROGRAM S3455(3),07-25-78 (GWG) SRQ PROGRAM
C
C SYSTEM PREPARATIONS:
C SET THE E BIT IN THE DEVICE CONFIGURATION WORD
C UNBUFFER THE EQT
C
C THE RTE SAVE RESOURCES OPTION HAS BEEN
C USED IN THIS PROGRAM. IT IS SCHEDULED
C ONCE MANUALLY FOR SETUP, THEN 10 TIMES
C BY 3455A INTERRUPTS.
C
```

Figure 7-8. 3455A Service Request Measurements

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[2]See the HP-IB Users Manual (59310-90064) for more detailed information.

```
C RMPAR IS CALLED 10 TIMES.
C
      DOUBLE PRECISION A(10)
      INTEGER          IPM(5),IPRG(4),ISTT(2),ISTAT(10)
      COMMON           ILU,ILST,IDLU
      DATA             IPRG/5,2HS5,2H34,2H2 /,LOOP/0/
      IF(INPRM(ID).EQ.2HNO)GO TO 999
      WRITE(ILU,100)IDLU
  100 FORMAT(" S3455A: SRQ PROGRAM SETUP",
     &        " IN PROGRESS FOR LU "I2"."/)
      CALL SRQ(IDLU,16,IPRG)
      IF(IERR(NN).LT.0) GO TO 20
      WRITE(IDLU,110)
  110 FORMAT("F1R7D1T2T3")
   10 LOOP=LOOP+1
      CALL EXEC(6,0,1)
      CALL RMPAR(IPM)
      ISTAT(LOOP)=IPM
      IF(ISTAT(LOOP).NE.65)GO TO 20
      READ(IDLU,*)A(LOOP)
      IF(LOOP.EQ.10) GO TO 20
      CALL TRIGR(IDLU)
      GO TO 10
  999 WRITE(ILU,130)
  130 FORMAT(" :RU,S3455,ILST,IDLU"/)
      STOP
   20 DO 30 JL=1,LOOP
   30 WRITE(ILU,140)ISTAT(JL),A(JL)
  140 FORMAT(5X,I6,5X,E14.6)
      CALL SRQ(IDLU,17)
      END
C
C
C
      FUNCTION IERR(N),07-26-78 (GWG) HANDLE BUS ERRORS
      COMMON ILU,IDLU
      I=IBERR(IDLU)
      IERR=0
      IF(I.EQ.0)GO TO 10
      IERR=-I
      WRITE(ILU,20)I,IDLU
   20 FORMAT(" S3455: BUS ERROR "I2" ON LU "I2"."/)
   10 RETURN
      END
```

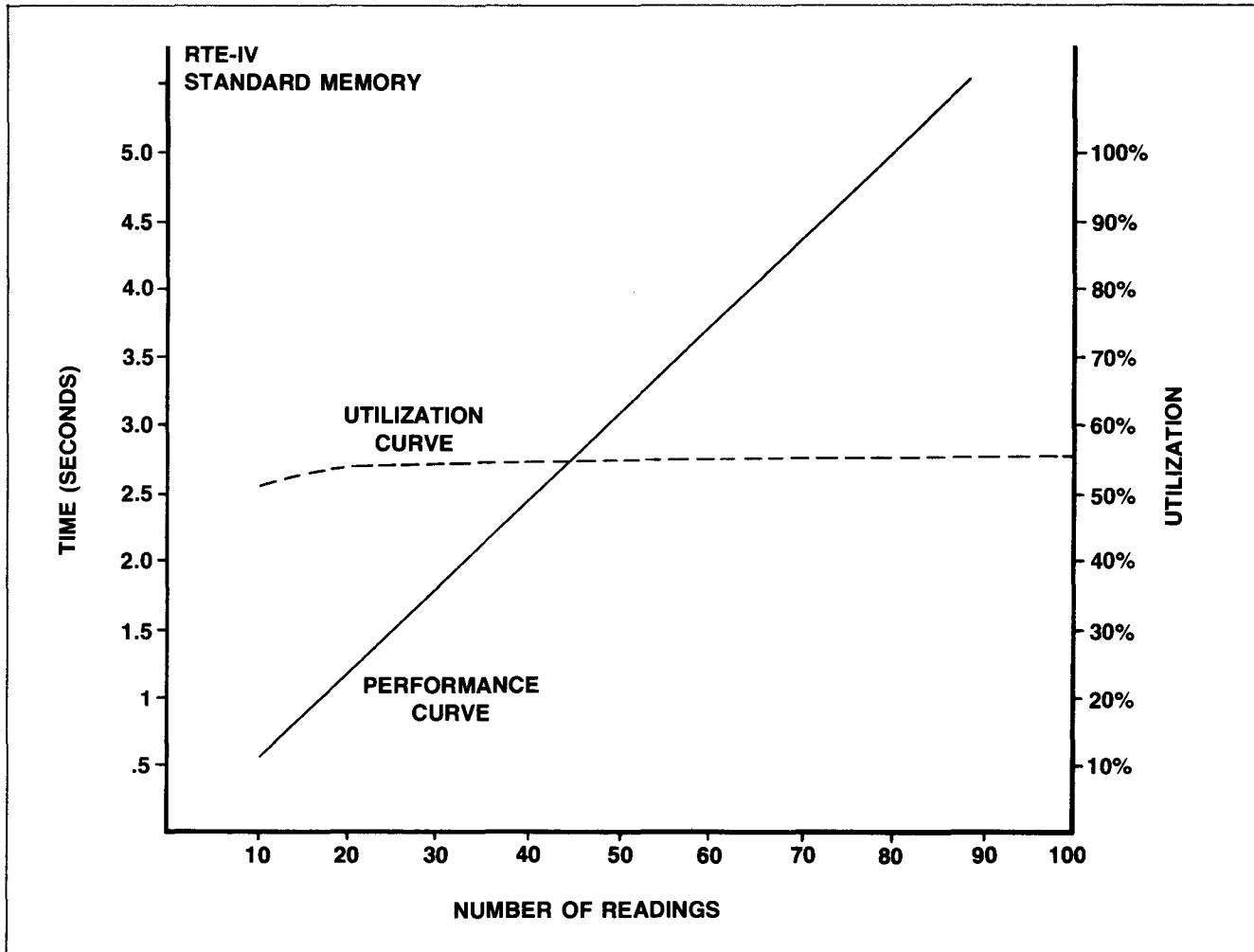**Figure 7-8. 3455A Service Request Measurements (Continued)**

Figure 7-9. 3455A Performance Curve

```
0046 C ----------------------------------------
0047 C ENTER USER STATEMENTS OUT OF TEST HERE.
0048 C
0049      WRITE(IDLU,5000)
0050 5000 FORMAT("F1R7T2T3A0D0H0")
0051 C
0052 C
0053 C ----------------------------------------


0061 C ----------------------------------------
0062 C ENTER USER STATEMENTS FOR TEST HERE.
0063      DO 100 IJ=1,ILN
0064      CALL TRIGR(IDLU)
0065      READ(IDLU,*)A
0066 C USER STATEMENTS FOR TEST END HERE.
0068 ----------------------------------------
```

Figure 7-10. 3455A Input Statements

Performance

Performance in an RTE system is dependent on several factors including:

1. The number of peripherals (EQT's) in the system.

2. The number of programs in the time list.

3. The priority and type of program interacting with the 3455A.

4. Whether or not output buffering has been allocated to the bus.

5. Whether or not DMA has been allocated for the 3455A.

6. Which functions (mode selection, range, high or low resolution, auto calibrate, etc.) are selected on the 3455A.

Application Note AN 201-4 gives an excellent description and breakdown of 3455A I/O characteristics during a performance evaluation. These details will not be reiterated here.

Typically, the 3455A is not considered to be a "fast" device compared to other devices on the HP-IB. When transferring data in the interrupt mode (when an interrupt is generated for each byte of information input), approximately 16 readings may be obtained per second (assuming all of the conditions above, except buffering, are optimal). The 3455A is actually capable of outputing 22 readings per second maximum rate. When these high performance characteristics are desired, a special I/O driver which sacrifices the generalities of HP-IB is available and can be used. The features and capabilities of this software are documented in Application Note AN 201-7 (part number 5953-3004).

Figure 7-9 shows a typical 3455A performance graph (time vs. number of readings taken) when the device is programmed as shown in Figure 7-10. Note that DMA was not allocated and buffering was turned off. The readings were formatted into binary using free field input in FORTRAN.

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