Programming the HP 4145B and HP 4142B with a PC

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INTRODUCTION

Today's research and manufacturing engineers are being pressured to improve productivity while reducing costs. To remain competitive in the fast-paced electronics marketplace, engineers must reduce product design cycles. Testing the finished product must be accomplished in the shortest possible time and in the most repeatable manner. Both of these requirements are causing engineers to rely heavily on computers to automate the process.

The personal computer is now commonplace on the design engineer's bench. These powerful machines feature software packages that allow the novice programmer to quickly analyze devices. Now with the low cost of the personal computer, teamed with the power of custom software, engineers can significantly speed the development and analysis of their devices.

ABOUT THIS GUIDE

This guide describes how a personal computer can be used to program the HP 4145B Semiconductor Parameter Analyzer or the HP 4142B Modular DC Source/Monitor via the IEEE 488.2 interface bus. Many programming fundamentals, examples, and sample programs are provided to get you started and to help overcome some of the hurdles a first-time programmer faces.

There are many different types of computers, software, interface cards, and instrument commands that we could discuss. However, this guide is not intended to be all inclusive. That is, it is not a tutorial on HP-IB, programming a personal computer, or the full HP-IB capability of the instruments. It is intended to demonstrate the basic concepts of HP-IB communication and provide sufficient information and examples to get you started. It is meant to be used with the knowledge contained in the documents listed in the "References" Section.

CONFIGURATIONS

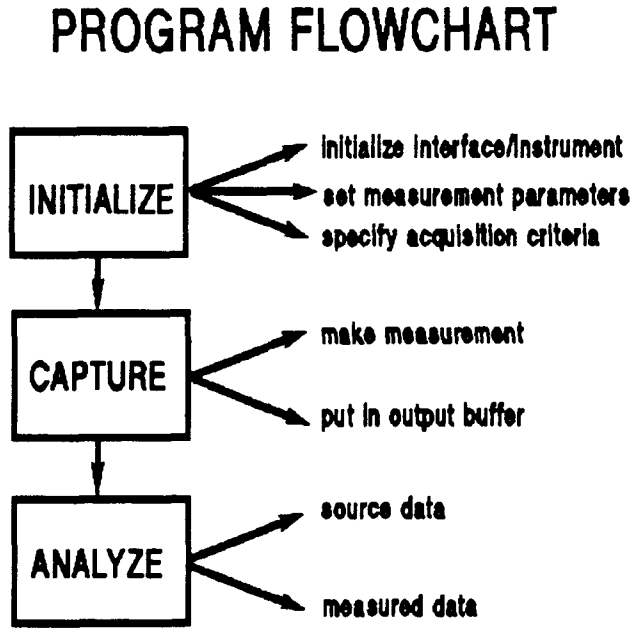
We will use various combinations of the following configurations in this guide and the disk provided. Although the example programs and the text are based on Instrument BASIC and QuickBASIC, the text content can be valuable for programming in other languages. The subroutine calls are the same and the method of passing information to and from the instruments still apply.

PC:	HP Vectra 386 or IBM/AT (compatible) with 4Mb RAM
Software:	HP Instrument BASIC for Windows - E2200A (Rev A.00.00) Microsoft QuickBASIC (version 4.5) Microsoft Windows (version 3.0)
IEEE 488.2 interface cards:	Hewlett-Packard 82335B HP-IB card (Windows) National Instruments GPIB-PCIIA card

NOTE: The contents of this guide are also applicable to the 4145A.

PROGRAM FUNDAMENTALS

In this section we are going to discuss the three fundamental parts of a program. The program flowchart below may help visualize the three steps.



INITIALIZE

First, initialize the HP-IB interface and the instrument. This step ensures consistent, repeatable performance of the program. Without these initialization procedures, a program may run one time, but not function properly the next time. This may be due to some setting change made either from the front panel or HP-IB which may drastically change the configuration of the instrument. Second, configure the instrument and set the measurement parameters. You must correctly specify the output channels before proceeding. Finally, specify the acquisition criteria.

Initializing the HP-IB Interface

CALL IORESET sets the HP-IB interface to:

interface timeout = no time limit
interface EOI mode enabled
cr/lf selected as EOL
lf established as the IOMATCH default

CALL IOCLEAR clears the interface by:

terminating any bus communication in progress (UNTalk, UNListen)
clear all serial poll status bits
clear the input and output HP-IB buffers
clear the error queue and key register
stop any measurement or acquisition processes

CALL IOTIMEOUT sets an interface timeout value in seconds to handle I/O operations that do not complete. For example, the HP-IB cable is not attached or the instrument address is not correct. Once the HP-IB interface and instrument are initialized, the I/O timeout should be reduced, otherwise the controller will 'hang' if the instrument does not respond. If the instrument does not respond within the allotted time, the controller will abort the I/O operation and report an error condition. Once again, all parameters passed to an HP-IB subroutine are variables. To specify an I/O timeout limit of 10 seconds, use the following:

```
TIME = 10
CALL IOTIMEOUT(ISC,TIME)
```

Initializing the Instrument

The *RST is a common command that resets the HP4142B to a known default configuration. Using this command will ensure that the instrument is in a known state before configuring it. Using the *RST command will ensure very consistent, repeatable results. Without the *RST, a program may run one time, but the program may give different results the next time if the instrument is configured differently.

The HP4145B does not have a command to reset the instrument to a known default state. The menus retain the same values from the previous acquisition unless overwritten. Therefore, it is very important to specify all setup conditions for each test. The HP4145B boots up with the default configuration.

Specifying the Acquisition

From the front panel of the HP4145B, the acquisition mode is set by pressing the appropriate measurement key (single, repeat, or append). For the normal front panel run mode, this is the only control that needs to be made. When programming the instrument over the bus and using the "MD" command, the acquisition mode is specified by using a 1,2, or 3 respectively.

CAPTURE

At this point the instrument and interface are completely configured. The trigger command can now be executed. The trigger command clears the data buffers, acquires data for the requested channels to the specifications that have been set, and finally stops the acquisition process when complete, displaying the signal on the HP4145B display.

The HP4145B measurement command is "MD". The HP4142B measurement command is "XE". However, even though the instrument has been properly initialized and set up, measurements cannot yet be made. It must be noted that when the instrument is responding to HP-IB commands, it is in an interrupt mode, and the data acquisition process is being held off. Changes to the instrument's configuration invalidate previously collected data. As a result, if a measurement is requested immediately, there may not be sufficient data available to analyze. Therefore, it may be required to poll the bus to determine the HP4145B response byte. Serial polling is not required with the HP4142B.

Aquired data must first be sent to the output buffer (automatic with HP4142B) before being transferred to the computer or internal disk of the HP4145B. The 4145B data format is different from the 4142B. (See instrument Operation manuals for details)

ANALYZE

Once the data has been captured, analysis can begin. The HP4145B display capabilities allows you to use markers, lines, and user functions on the front panel. The data can also be transferred from the buffer and displayed on the computer, saved to the PC disk drive, or printed to an external device. In the sample programs, a disk file is opened, the measured and source data are written to a file, and the file is closed.

SAMPLE PROGRAMS

The sample programs on the disk are written for both the HP 4145B and HP 4142B using both HP Instrument BASIC and Microsoft QuickBASIC with the HP-IB and National PCIIA interface cards. The sample programs follow the format of initialize, capture, and analyze as discussed earlier. The complexity of the programs range from a simple buffer dump to an extensive data output handling routine. Each program has its own comments written into the program which explain each step. You can write your own custom program by selecting and modifying these steps.

Both the HP Instrument BASIC and Microsoft QuickBASIC sample programs contain the following fundamental information:

HEADER INFO:	Define global variables and constants; specify include files; call the various functions.
INITIALIZE:	Initialize HP-IB interface and the instrument; setup the instrument and measurement parameters.
SEND COMMANDS:	Send appropriate programming commands to the instrument.
CAPTURE DATA:	Perform simple parametric measurements.
TRANSFER DATA:	Bring data from the instrument buffer into the computer.
ANALYZE DATA:	Display on the computer, store to a PC disk file, or print to an external device.
HANDLE ERRORS:	Include error checking subroutines to report any errors.

DEVICE ADDRESSING WITH THE HP AND NATIONAL CARDS

HP-IB INTERFACE CARD

The address is composed of two parts:

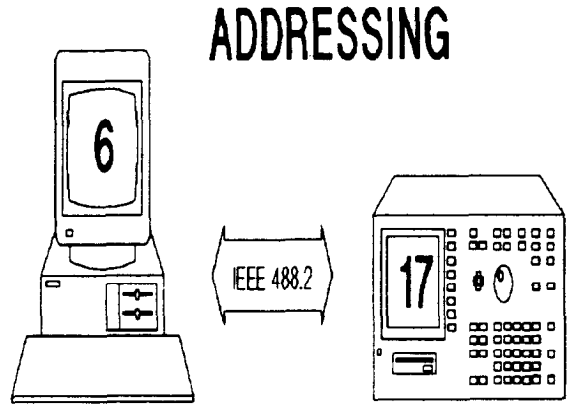
1. Interface Select Code (ISC)
2. Instrument Address

Each interface card has its own ISC address set on the card. This address is used by the subroutine calls to direct commands and communications to the proper interface. A PC can use multiple interfaces, but each card must be assigned to a unique ISC. The hardware ISC can be selected, or changed, by using the switches found on the interface card. Because some address combinations may result in internal controller bus conflicts, please refer to the installation section of your interface card manual.

Each instrument on the IEEE 488.2 bus also must have a unique address that is between decimal 00 and 30. The instrument address must be set with the bit switches on the back of the HP 4145B and HP 4142B as described in their respective Operating manuals.

The factory default values for the ISC address is 7 and the instrument address is 17. The ISC address is set to 6 in our example programs. Parameters passed to the subroutine calls must be passed as variables. The reference variable passed to a subroutine call must include not only the device address, but also the correct interface select code.

DEVICE ADDRESS = (Interface x 100) + Instrument
= (6 x 100) + 17 = 617



NATIONAL INSTRUMENTS PCIIA INTERFACE CARD

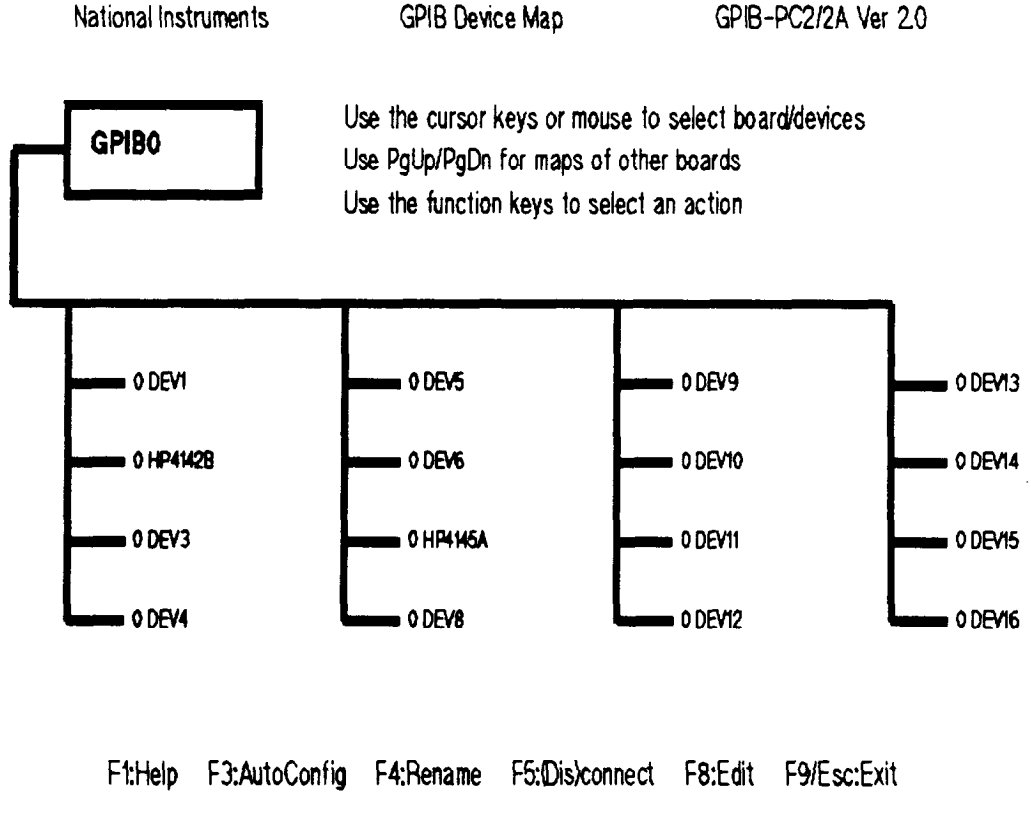
The address is composed of two parts:

1. Interface Card Number
2. Instrument Address

Up to four interface cards may be installed that can handle up to 32 instrument addresses each. The card number is set to 0,1,2, or 3 by a switch on the card. The default card number is 0 for one card installed.

Instrument addresses default to DEV1, DEV2, ..., DEV32 unless otherwise specified. These can be modified by running the IBCONF.EXE file found in the GPIB-PC directory. When using QuickBasic, the National card defaults to respond to any instrument address from 0 to 15. The HP 4145B and HP 4142B factory default address is 17. Change the instrument address to something 15 or less or edit the ICONF.EXE file to tell the card to respond to the second block of 16 address (16-31).

The following is an example of the GPIB Device Map. Here we see the name "HP4142B" at address 02, and "HP4145A" at address 07.



DIFFERENCES BETWEEN THE HP AND NATIONAL INTERFACE CARDS

While OUTPUT and ENTER statements are supported on both HP and National cards, there are a few subtle differences in the operation of the two classes of cards:

Pressing the "Scroll Lock" key or "Stop" on the control pad aborts any active I/O statement using an HP card. That won't work with a National card; to deal with this problem, IBASIC sets a default 10-second timeout for National cards that are not specifically configured with a timeout in the GPIB.INI file. This means that you should NEVER set a timeout of 0 in WIBCONF; this can cause your IBASIC program to hang indefinitely on I/O statements accessing a National card.

Timeouts work differently on HP and National cards. IBASIC allows you to set timeouts from 0.001 to 32.767 seconds; an HP card uses the exact timeout value specified. However, National cards support only a discrete set of timeout values: 10us, 30us, 100us, ... , 30s, 100s

To deal with this, IBASIC rounds up to the next higher timeout value for National cards; if you specify a 2.01 second timeout for a National card, it is actually set to 3 seconds. The default timeout is, as shown in the previous section, set in the WIBCONF utility.

Another difference regarding timeouts is that on an HP card, the timeout applies to each byte. On National cards, the timeout applies to the entire statement, which may result in a timeout if you are transferring a large number of bytes and your timeout is too short.

IBASIC supports the following HPIB CONTROL and STATUS registers, relative to the RMB implementation; those registers supported by HP cards are marked under the "H", those supported by National cards are marked under the "N".

PROGRAMMING WITH HP INSTRUMENT BASIC

Instrument BASIC for Windows is a complete programming environment designed to provide measurement results quickly. It provides built-in tools for instrument I/O, graphics, and reporting. It goes far beyond simply getting measurements from an instrument. I-BASIC provides all the capability needed to create simple to complex test programs.

Header Information

Instrument BASIC has unified I/O; in other words, you can communicate with instruments just as if they were files. To simplify reading and writing, you assign an I/O path to the instrument's device selector with the ASSIGN keyword. You must include an assign statement before any HP-IB commands are sent.

When using I-BASIC, the HP card is mapped into select code 7 by default and the National card is mapped into select code 8. We will use select code 6 and the default instrument address of 17 for all the example programs. Therefore, the device address is 617. (Refer to the Device Addressing sections for complete details)

```
ASSIGN @Hp4145 TO 617
```

Sending Commands

Instrument BASIC gives you powerful commands like OUTPUT and ENTER to set up and get measurements.

```
OUTPUT @Hp4145;"BC"
```

Transferring Data to the PC

Instrument BASIC automatically formats data for numbers, strings, and arrays. Use OUTPUT to ask for an instrument reading. Use ENTER to read the value from the instrument.

```
OUTPUT @Hp4145;"DO 'IB'"
ENTER @Hp4145 USING "#,12D,X";Ib(I)
```

Storing Data to the PC disk

The default format mode is to read and write files in an I-BASIC specific form. To specify a text file, use the FORMAT ON option.

```
ASSIGN @File TO "Datafile"; FORMAT ON
```

Handling Errors

Instrument BASIC provides automatic error-checking on all of your code, including I/O commands. You don't have to worry about hanging up the interface and computer. You can also click on the handy "STOP" button to cancel a program at any time.

To prevent other errors from unexpectedly stopping execution, trap the errors and handle them in your program. I-BASIC provides many simple to use keywords for error handling.

PROGRAMMING WITH MICROSOFT QuickBASIC

Links to MICROSOFT QuickBASIC Libraries

To run programs in Microsoft QuickBASIC, you must first link to various libraries and include files. The interface card Command Library disks contain an INSTALL program that copies the BASIC Library files to your system for you. The location of these files will depend on your computer configuration and where you specify the files to be installed. Refer to your interface manual for details. You must boot QuickBasic with the QB /L command.

HP	National
QB /L C:\HPIB\QBHPIB.QLB	QB /L C:\GPIB-PC\QBASIC\QBIB

Header Information

The header for the programs set up the necessary error status variables, declares some working variables, contains related COMMON statements and establishes an error handling routine. The $INCLUDE statement links in setup conditions for the interface cards. Your program will not respond to any commands without this line of code.

HP	National
REM $INCLUDE: 'QBSETUP.BAS'	REM $INCLUDE: 'QBDECL.BAS'

A variable name is used for the instrument address. It is necessary to properly dimension any shared variables. The dev variable must be defined as long to be used as the instrument address with the HP-IB card. The IBFIND statement is the method used to setup the address of the instrument using the National card. It reads information defined in the ICONF.EXE file. The following example uses the name 'HP4142B' which was previously setup in ICONF.EXE. The name must be spelled exactly as specified, including the same upper or lower case letters. The dev% can be any arbitrary integer variable and does not have to be initialized. (See the Device Addressing section for more details)

HP	National
DIM SHARED dev AS LONG dev = 617	DIM SHARED dev% CALL IBFIND("HP4142B", dev%)

Sending Commands

To simplify the format of the sample programs when sending messages to the instrument, a generic output statement has been written. The use of the CALL statement simply makes the code easier to read.

It is important to remember when using the National card to be sure to include a linefeed character CHR$(10) to terminate commands sent to the instrument. This is a major difference between using the National and HP library commands. The HP card does not require the linefeed character.

HP

```
DECLARE SUB hp4145 (code$)
CALL hp4145("BC")

SUB hp4145 (code$)
    CALL IOOUTPUTS(dev, code$, LEN(code$))
END SUB
```

National

```
DECLARE SUB hp4145 (code$)
CALL hp4145("BC")

SUB hp4145 (code$)
   CALL IBWRT(dev%, code$ + CHR$(10))
END SUB
```

Transferring Data to the PC

HP

```
max.len% = 800: actual.len% = 0
data$ = SPACE$(max.len%)
CALL IOENTERS(dev, data$, max.len%, actual.len%)
```

National

```
max.len% = 800
data$ = SPACE$(max.len%)
CALL IBRD(dev%, data$)
```

Storing Data to the PC disk

The following command can be used with the HP-IB interface card for storing the captured data to the PC disk drive. Refer to National's manual for the equivalent command.

```
OPEN "Data.prn" FOR OUTPUT AS #1
```

Handling Errors

Errors may occur while communicating over the bus. To avoid hanging up the interface and computer, it is recommended that an error handling procedure be used to report the errors.

An error handling routine is included with QBSETUP.BAS. If a subroutine detects an error, the error number is placed into the variable called "PCIB.ERR." A text error message is placed into the variable called "PCIB.ERR$." Your program can examine PCIB.ERR to find the error number and the string PCIB.ERR$ to find the error message text.

After each subroutine call, if the value of the variable PCIB.ERR is zero, no error conditions have been detected. However, if its value is not zero, then the error message can be printed by transferring control, via the BASIC error trapping facilities, to an error handling routine in the QBSETUP.BAS file. This control transfer looks like:

```
IF PCIB.ERR< >NOERR THEN PRINT PCIB.ERR$
```

It is important to know that the variables PCIB.ERR, PCIB.BASERR, and NOERR are specified as COMMON in QBSETUP.BAS. This means that in the main program or any functions, these variables are recognized. However, if using subprograms (as in the sample programs), they will not be part of the subprogram environment and must be specified as SHARED variables in any subprogram where they are used.

For simplification, the error detecting/reporting routine is not included in every example program. If you plan to include any of these examples in your own programs, be sure to add the appropriate error detecting/reporting. Once program development is complete, some of the error checks can be safely eliminated.

PROGRAMMING THE 4145B & 4142B

As we discussed in the "Program Fundamentals" section, there are typically three basic functions that an engineer will want a computer and a HP 4145B or HP 4142B to do in a programming environment:

1. set up the instrument
2. make measurements
3. retreive setup information and measurement results for analysis by the computer

Of course, this is not the limit of flexibility of a controller and the instruments, but other more complicated tasks are accomplished with a combination of these three basic functions.

Since programming the HP 4145B is quite different from the HP 4142B, we will indicate which model is applicable for the examples. To be successful in merging the HP 4145B and computer, you first need to understand how to make the measurement using the front panel. The HP 4142B does not have front panel programming capability.

Many front panel and programming operations are similiar:

Front panel:	push a key, use the menus
Programming:	send a command, use the subsystems

Several front panel and programming operations are different:

Front panel:	set value/div, choose graphics display
Programming:	send the full scale range, get data that can be plotted on computer screen or converted to engineering units

Computers communicate with instruments by sending and receiving messages over the bus using input/output (I/O) statements provided in the programming language.

Messages for programming the instruments appear as ASCII character strings embedded inside I/O program statements. Each message consists of a device address, a program message, and a terminator. The address uniquely identifies one of the instruments on the bus while the program message specifies the action to be taken by that instrument.

Message Basics: Command/Query

There are two basic forms of messages: commands and queries. The format of the command and query are the same, but the query usually has a question mark (?) attached to the message. The function of the command and query are vastly different.

> Commands are used to set up the instrument or to specify that an action be taken.
> Queries are used to find out how the instrument is set up or to get results.

A query causes the instrument to put data into the output buffer of the instrument. This data must be read from the instrument into the computer using an input statement. If the data is not read from the instrument, and a new command or query is sent to the instrument, the error message "QUERY INTERRUPTED" is displayed.

Message Syntax

To program the HP 4145B or HP 4142B via the IEEE 488.2 bus, you must have some understanding of the message format and structure expected by both instruments. A complete set of rules is contained in the programming section of the HP 4145B Operation manual and the HP-IB Command Reference manual for the HP 4142B.

The basic difference between the two instruments is that the HP 4145B uses a hierarchical programming structure and the HP 4142B uses low level programming.

4145B: "<Direct Page> <message> <parameters>"
4142B: "<message> <parameters>"

Examples of Commands:

4145B/4142B: **BC**

Clears the output data buffer that stores measurement data and query command response data.

4145B:	**CA1**	Set auto calibration ON.
4142B:	**CA4**	Performs self-calibration on the module in slot# 4.

Examples of Queries:

4145B:	**ID**	Puts the revision# of the ROM and Operating System in the output buffer
4142B:	***IDN?**	Requests the instrument model number and the ROM version number, and stores the results in the output data buffer.
4142B:	**ERR?**	Transfers error codes from the error register to the ouput data buffer.

Three Message Types

There are three basic message types defined by IEEE 488.2:

1. common commands
2. root level commands
3. subsystem commands

1. Common Commands

The IEEE 488.2 Standard designates a set of commands that all instruments must have to guarantee that all instruments have a minimum set of capabilities. All of these commands are prefaced with an asterisk .

Examples of Common Commands (HP 4142B):

*RST	Resets the mainframe and all units to the initial settings
*OPC?	Used to determine when it has completed a measuerment or setting

2. Root Level Commands

The root level commands control many of the basic operations of the instrument.

Examples of Root Level Commands (HP 4145B):

IT1	Sets the measurement integration time to SHORT
DR0	Data Ready Service Request OFF

3. Subsystem Commands/(HP4145B -Direct Paging)

Configuring the instrument usually means setting the function in the appropriate menu. Similar functions are grouped together under a subsystem. For example, the source mode, sweep mode, start, stop, and step values are all grouped together under the Source Setup page (program code "SS") on the HP 4145B.

Example of Direct Paging Commands (HP 4145B):

"SS VR1,0,1,.05,50E-3,IP 10E-6,10E-6,4,3" (See HP 4145B Operation Manual for complete details)

HP 4145B PROGRAMMING HINTS

Program Flow

The 4145B cannot store data in its buffer unless a complete measurement has been made including setting the channel definition page, source setup page, measurement and display page, and graphics plot or list page.

1) Program all pages and display the data on the 4145 screen.

2) Do a serial poll until bit 0 is set to 1 (Data Ready) and use the 'DO' command to get the data from the display to the 4145 instrument buffer.

3) Read the data from the buffer. The data will just be the measured results. The 4145B does not store the corresponding measurement setup values. For this reason, it is usually necessary to read the results into an array in computer memory. Measurement setup values can be generated from the user program and a similar array is established. This allows measurement setup and results to be printed or plotted conveniently from computer memory. Data stored on the HP 4145B disk contains measurement setup and results.

The programming examples show the raw measured data which can be printed out from the 4145 buffer (BD), as well as formatted data (FD), where the data has been transferred to arrays in computer memory for tabular printout.

HP-IB switch

There is a switch on the back of the 4145A/B which determines the output data delimiter. When the bit switch is set to 1 (CR/LF), it allows the instrument to talk directly to a stripchart recorder bypassing the HP-IB bus. The settings must be in the factory default HP-IB positions for normal instrument control. Make sure to cycle the power if you change the switch.

Bit Switch 6 (Data Form Bit)	Comma (,)
Bit Switch 7 (EOI; End or Identify)	EOI on

HP 4142B PROGRAMMING HINTS

Program Flow

This program flow description lists the major order of events required to generate data for a family of curves similar to a 4145 display involving VAR1 and VAR2 sweeps.

1) Reset the instrument with the *RST command. This assures all HPIB commands default to factory parameter settings and clears the data buffer.

2) Chose the format of the buffer data with the FMT command. The factory default is ASCII data with header and measured data (results) only. You can chose to store measurement setup data in the buffer or you can choose to delete the header.

Hint:

It is nice to have the 4142 retrieve the measurement setup values since it saves the need to create it with FOR NEXT loops in program code. The disadvantage is it decreases the data acquisition speed by 2. Filling the data buffer with redundant measurement setup values for every sweep effectively halves the throughput. Normally only measured data is stored in the buffer for this reason.

Hint:

The header can be used to note measurement integrity. A three character header is used to sense if any problems occurred, such as compliance, oscillation, etc. You may want to use this feature if there is doubt about fixturing or test conditions of your measurement.

3) Choose the channels you will use. This is done with the connect (CN) command. It closes the output relay of the channel so a signal can be applied to the device. No further programming of the channel is possible until the CN command has been issure.

4) Set the channel source conditions. An example is using the WV command to set a sweep start, stop, step, compliance values.

5) Set the measurement mode with the MM command. An example is measuring the current from a voltage sweep.

Hint:

It might seem that the MM command is reduntant. But remember that many channels in the 4142 can be set to various spot or swept conditions. The MM command picks exactly which channels you wish to monitor.

6) Trigger the measurement with the XE command. This command automatically stores the data in the 4142 buffer with no need to issue a poll command for completion of this task.

7) Turn off the channels being used with the CL command. This opens the output relays to each channel.

Hint:

Use of the CL command is a safety feature to remove any voltages from the device. It can prevent shock hazards as well as prevent thermal runaway (excessive heating) of the device. The CL command also turns off the standby power required for the HCU and HVU. This conserves mainframe power.

Control Software vs Low Level Programming

To eliminate dealing with the low level programming of the 4142, the factory provides a high level TIS (test instruction set) which is written in HP BASIC. It is documented in the Control Software Manual for the 4142B. If you are working on a big multi-user test shell, you may want to consider writing such drivers in your preferred PC language. The factory Control Software was designed to run on HP workstations or the PC co-processor card. But similar driver commands can be easily written in QuickBasic or C for the PC.

For simple projects, or for programs demanding the absolute top speed, you are better off programming at the HPIB command level.

DIFFERENCES BETWEEN PROGRAMMING THE HP4145B & HP4142B

HP-IB Command Structure

The 4142 is not programmed in a hierachical command structure like the channel definition, source setup, measurement setup, and display mode setup of the 4145. The 4142 is programmed at a lower level which allows the user to streamline the command structure or even create higher level heirachical command structures. This lower level of HP-IB commands also provides much higher throughput test capability. It is possible to get data from the 4142 buffer as soon as the measurement is triggered. There is no need to output the data to the buffer like the 4145.

HP 4142B Enhanced Capability

Another major difference is the expanded capability of the 4142 over the 4145. There are a total of 10 measurement modes (spot, staircase sweep, pulsed sweep, quasi-pulse, etc). Measurements can be made on two swept channels at once or any number of spot channels. In addition, the measurements can be output in a variety of formats to the buffer.

Decreased User Friendliness of HP 4142B

In order to incorporate all these new HP-IB commands, and to maintain high throughput, some user friendliness of the 4145 was deleted. For example, there is no concept of primary and secondary sweeps (VAR1 and VAR2) as with the source setup paging in the 4145. The 4142 only handles single sweeps. A family of curves involving multiple secondary sweeps must be constructed in the program code using a FOR NEXT loop. This is very easy to do in code.

Increased Speed of HP 4142B

Because the 4142 operates with lower level commands and does not have to support a front panel display mode, capturing data can be 5 to 10 times faster. In the programming examples of this document, an effort was made to time stamp measurement capture times. Note the speed increase for the same measurements made with the HP4142 and HP4145.

	HP4145B	HP4142B
instrument reset capability	N	Y
error query buffer	N	Y
serial polling required	Y	N
direct paging commands	Y	N
data formats		
with header	Y	Y
w/o header	N	Y
with source data	N	Y
w/o source data	Y	Y
sweep setup	step size	no. of steps

4145B DATA TO ASCII

One of the nice features of the HP4145B is its built-in disk drive. The HP4145B was originally designed for benchtop use. The built-in disk drive provides a means of storing instrument setups and data for later analysis. The HP4145B was developed in the early 80s before the personal computer became such a prominent instrument controller. The HP4145B stores data as binary files in a LIF format which is common to the HP BASIC workstations. Unfortunately, many customers use analysis software which require ASCII data. There are three methods to get the 4145B binary data into an ASCII format.

1. Program the 4145B with a PC and store the data to the PC drive.
   See sample program 45HPIBDO.IBW or 45HPQBDO.BAS

2. Retrieve stored data from the 4145B drive using a PC and re-save it to the PC drive.
   See sample program 45DISK.IBW

3. Convert the 4145B binary data on the disk to ASCII.
   Use LIF Utilities to read the 4145B disk and 45ASCII.IBW program to convert the data to ASCII.

The following is is a step-by-step procedure for converting 4145B (BDAT) data files into ASCII for importing into other analysis packages or spreedsheets.

NOTES: The 45ASCII.IBW program only accepts graphics data files (not list,schmoo, or matrix data)
The LIF to DOS file you convert and the 45ASCII.IBW program must reside in the same directory on your hard disk.
The converted ASCII files are saved on hard disks only. If you try to save ASCII files to the floppy drive, you will get an "out-of-bound" error.

The 45ASCII.IBW program is unsupported and is not guaranteed. You may need to modify it to fit your specific needs.

HOW TO TRANSFER FILES FROM 4145A TO 4145B FORMAT

You cannot directly read or copy files from a 4145A disk with a 4145B or controller. The 4145A uses preformatted 5 1/4" floppy disks only (16261A) and the record format is not compatible with other formats such as LIF or DOS. You must use the 16267A File Transfer software to convert the files into a LIF format. This is a simple procedure that only requires a HP4145A, HP4145B, and a HP-IB cable. If it isn't possible to use the 4145A and 4145B side-by-side, you can use a BASIC controller.

Run LIF Utilities program

1) Insert 4145B data disk into 3 1/2 " drive on the PC (B:)
2) Select LIF Catolog from the MAIN MENU
   LIF drive name: B: (F1 - Next Choice)
   LIF file name: Entire disk
   Show deleted files: No
   Output device: CRT
3) F5 - START (it takes a few seconds depending on how many files are on your disk)
   Data files will appear different than they appear in the 4145B catolog menu. The file name is changed to a 10 character name starting with the original name and ending with DAT. Any blanks are filled with "_".
   A file saved as "DTEST" with the 4145B will appear as "TEST_ _ _ DAT using LIF catalog.
4) F8 - LIF Cat Menu
5) F8 - Main Menu
6) Select LIF to DOS Copy
   LIF drive name: B:
   LIF file name: TEST_ _ _DAT (case sensitive)
   DOS directory name: . (current directory where lif.exe resides)
   Copy as: TEST.DAT
   File name conversion: truncate (F1 - Next Choice)
   Duplicate file name: Make unique name
   File format conversion: DOS text (BDAT, written with FORMAT ON)
7) F5 - START (The program will prompt you. Wait until the completed message appears)
8) F8 - Continue
9) F8 - Main Menu
10) ESC - Exit form LIF Utilities

Run Instrument BASIC for Windows

1) File Open . . . 45ascii.ibw file
2) Click RUN from the Control Pad
3) When prompted for an input file name, type the name of the file you converted from LIF to DOS (i.e. TEST.DAT). When prompted for an ASCII output file name, type any DOS filename. (The ASCII file will be saved as A_TEST.DAT if nothing is input). Be patient-the program takes a few minutes. It will prompt you when completed.

SAMPLE PROGRAMMING DISK

The sample program disk contains the following three programs using the HP4145B/HP4142B, HP/National interface cards, and I-BASIC/QuickBASIC. The sample device is a 2N3904 transistor.

BUFFER DUMP (BD)

This program measures the Vbe characteristics of the device. IV data is displayed as unformatted raw data directly from the instrument's buffer. This is a very simple starter program which is good for learning how to initialize the cards and the instruments, make measurements, and retrieve the data.

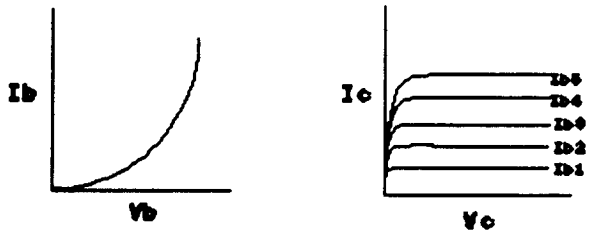
FORMATTED DATA (FD)

Same as buffer dump program except data is parsed to display the measurement point, Vb, and Ib in a column. Data in this format is very useful for analysis. It is much simpler formatting the data with Instrument BASIC than with QuickBASIC. This program also uses a timestamp to show how long it takes to initialize the cards and the instruments and make the measurements. The HP4142B is much faster than the HP4145B and the HP card is faster than the National card.

DATA OUTPUT (DO)

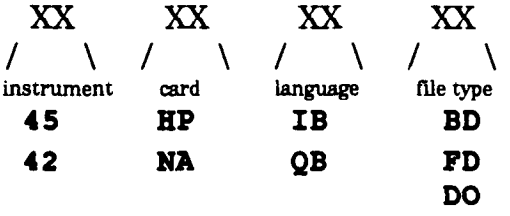
This program measures the Vc vs Ic characteristics of the device. The data is formatted for each measurement point, the X value (Vc), and Y values (Ic at each Ib). The data can be displayed on the screen, printed to a parallel printer, or stored as an ASCII file. This program also shows how to use error trapping by automatically aborting instrument control if the HP-IB communication fails.

Graphs of these programs would look similar to the following:



- buffer dump
- formatted data
- data output

The structure of the filenames are as follows:



HP 4145B

		IBASIC/HP-IB	QBASIC/HP-IB	QBASIC/National
buffer dump	**(BD)**	45HPIBBD.IBW	45HPQBBD.BAS	45NAQBBD.BAS
formatted data	**(FD)**	45HPIBFD.IBW	45HPQBFD.BAS	45NAQBFD.BAS
data output	**(DO)**	45HPIBDO.IBW	45HPQBDO.BAS	

HP 4142B

		IBASIC/HP-IB	QBASIC/HP-IB	QBASIC/National
buffer dump	**(BD)**	42HPIBBD.IBW	42HPQBBD.BAS	42NAQBBD.BAS
formatted data	**(FD)**	42HPIBFD.IBW	42HPQBFD.BAS	42NAQBFD.BAS
data output	**(DO)**	42HPIBDO.IBW	42HPQBDO.BAS	

There are many variables involved with these sample programs (instrument, interface card, language, and file type). Therefore, there is a README file which briefly highlights some of the major points of each program. The contents of the readme file and the program listings are in the appendix.

These are a few additional programs for manipulating the HP4145B data:

45DISK.IBW This I-BASIC program will get a binary data file from the 4145A/B disk drive and display the data on the PC. You can then save it to the PC disk or print it.

45ASCII.IBW This I-BASIC program converts 4145B binary data files into ASCII. It is first necessary to use LIF Utilities to read the 4145B disk.

45GRAPH.IBW This I-BASIC program takes an ASCII file that was converted using 45ASCII.IBW and plots the data to the graph display.

45LIST.IBW This I-BASIC program will list 4145B binary data to the PC display. It is first necessary to use LIF Utilities to read the 4145B disk.

45DRAW.IBW This I-BASIC program will draw 4145B binary data to the PC display. It is first necessary to use LIF Utilities to read the 4145B disk.

REFERENCES

The following reference material may be helpful to use during your programming journey. It is especially important to always reference the product manuals. This guide only covered very basic information from the appropriate manuals.

HP has a collection of no-charge publications that can help you find solutions to your measurement and design problems. All free literature is available through your local HP sales office or by calling the HP Customer Information Center at **800-752-0900 (US only)**. To receive the publication you want as quiclky as possible, please reference the publication number found on the back of each piece of literature.

MANUALS

PRODUCT	TITLE	PART#
4145B	Operation Manual	04145-90310
4142B	Operation Manual	04142-90010
4142B	HP-IB Command Reference Manual	04142-90110
4142B	Control Software Programming Manual	04142-90210
82335B	Using the HP-IB Interface and Command Library with DOS	82335-90006
E2200A	Installing and Using HP Instrument BASIC for Windows	E2200-90000

FREE LITERATURE

PRODUCT	TITLE	PUB#
4145B	HP 4145B Semiconductor Parameter Analyzer (Data Sheet)	5952-7838
4142B	HP 4142B Modular DC Source/Monitor (Data Sheet)	5091-1581 E
82335B	AN 1219-1: Using DDE for Test & Measurement Applications	5091-2950 E
82335B	AN 1219-2: Creating Instrument Control Apps w/Visual Basic	5091-2952 E
E2200A	HP Instrument BASIC for Windows Evaluation (3 1/2" disk)	5091-2947 EUS
E2080A	HP E2080A LIF Utilities for the PC (Data Sheet)	5952-2588
E2200A/82335B	HP Instrument Tools for Windows (Data Sheet)	5091-2985 EUS
82300C/82324A	HP Measurement Coprocessors for personal computers w/disk	5091-0240 E
Metrics	The Graphical Difference in Instrument Control & Data Analysis	Call US SSC

PROGRAM LISTINGS

HP 4145 PC programs

45HPQBBD.BAS HP 82335B, QuickBasic 4.5, 4145 buffer dump

Call hp4145 is a subroutine which simplifies the syntax for sending GBIB commands to the HP4145. Notice the LEN(code$). This parameter is necessary for the HP 82335B card. It keeps track of the length of code sent to the instrument and can be used to verify transmission.

45NAQBBD.BAS National PCIIA, QuickBasic 4.5, 4145 buffer dump

Call hp4145 is a subroutine which simplifies the syntax for sending GBIB commands to the HP4145. Notice the CHR$(10). This is a line feed character which must terminate each line of code. The CHR$(10) is needed for many HP instruments, though not all.

Format of data from the 4145 is A+DD.DDDE+DD, or 13 total characters for each number. The first character is a header signifing the nature of the data, N (normal), C (compliance occurred), etc.

45HPIBBD.IBW HP 82335B, HP Instrument BASIC for Windows, 4145 buffer dump

Similar to 45HPQBBD.BAS

45HPQBFD.BAS HP 82335B, QuickBasic 4.5, 4145 formatted data

This routine shows how to read data into an array and then print it in tabular form. Note 'Call hp4145("SS VR1," .....' This is an example of how to split long lines of commands into several short lines. The HP 82335 allows passing of parameters without the need to explicitly add "," as comma delimiters.

Max. len%=13 is used to read one data point at a time, as Ib vaules. Vb are calculated with 'vb(i)=str + (i%-1)*(inc)'

45NAQBFD.BAS National PCIIA, QuickBasic 4.5, 4145 formatted data

This routine shows how to read data into an array and then print it in tabular form. Note 'Call IBWRT(dev%, "SS VR1,"......' This is an example of how to split a long line of commands into several short lines. The line feed character is sent only once, at the end of the last segment.

Max.len%=13 is used to read only 13 characters at a time. The header char is stripped with the RIGHT$(data$, 12) command. The remaining string can then be converted to a number with VAL(data$).

The 4145 does not record the source data, only measured data. Vb data was calculated.

45HPIBFD.IBW HP 82335B, HP Instrument BASIC for Windows, 4145 formatted data

Similar to 45HPQBFD.BAS

45HPQBDO.BAS HP 82335B, QuickBasic 4.5, 4145 data output

This routine shows how to print directly to the screen, printer, or ASCII file. Error handling has been added to account for HPIB communication problems (ie incorrect address specified). HP timeout can be set to automatically terminate communication and prevent locking up the PC if

problems occur.

QuickBasic allows using the PRINT #1 syntax to print to an OPEN screen, com port, or file. The writing to the file differs only in the formatting of the data. File data is most useful with comma delimeters, and all other header or tabbing info removed. File name defaults to DATA.PRN.

Abritrary parameter passing is permitted in this routine, though the screen and printer outputs are limited to five (Y1...Y5) columns of measured data, one column of source data, and one column of data numbers (full page width).

45HPIBDO.IBW HP 82335B, HP Instrument Basic for Windows, 4145 data output

Same as 45HPQBDO.BAS, except an enhancement has been added to the file writing routine. Code has been added to prompt the user for a file name and whether to purge any duplicate file name. I-BASIC does not automatically overwrite files, as is the case with QuickBasic.

HP 4142 PC programs

42NAQBBD.BAS National PCIIA, QuickBasic 4.5, 4142 buffer dump

Call hp4142 is a subroutine which simplifies the syntax for sending GBIB commands to the HP 4145. Notice the CHR$(10). This is a line feed character which must terminate each line of code. The CHR$(10) is needed for many HP instruments, though not all.

Format of data from the 4142 is +DD.DDDDE+DD,+DD.DDDDE+DD, or 26 characters for measured data, source data pairs when using FMT2,1. FMT2,0 deleters the source data. You can also add header information with FMT1. Header is three characters such as NAV (normal, #1 chan, voltage), or CBI (compliance occurred, #2 chan, current).

```
FMT1,0       AAA+DD.DDDDE+DD,
FMT1,1       AAA+DD.DDDDE+DD,AAA+DD.DDDDE+DD,
FMT2,0       +DD.DDDDE+DD,
FMT2,1       +DD.DDDDE+DD,+DD.DDDDE+DD,
```

42HPQBBD.BAS HP 82335B, QuickBasic 4.5, 4142 buffer dump

Same as 42NAQBBD.BAS

42NAQBFD.BAS National PCIIA, QuickBasic 4.5, 4142 formatted data

This routine shows how to read data into an array and then print it in tabular form. FMT2,1 was used to get ASCII data pairs, without header information. This is the simplest way to retrieve pairs of data.

42HPQBFD.BAS HP 82335B, QuickBasic 4.5, 4142 formatted data

Same as 42NAQBFD.BAS

42HPQBDO.BAS HP 82335B, QuickBasic 4.5, 4142 data output

This routine shows how to print directly to the screen, printer, or ASCII file. Error handling has been added to account for HPIB communication problems (ie incorrect address specified). HP timeout can be set to automatically terminate communication and prevent locking up the PC if problems occur.

QuickBasic allows using the PRINT #1 syntax to print to an OPEN screen, com port, or file. The writing to the file differs only in the formatting of the data. File data is most useful with comma delimeters, and all other header or tabbing info removed. File name defaults to DATA.PRN.

Abritrary parameter passing is permitted in this routine, though the screen and printer outputs are limited to five (Y1...Y5) columns of measured data, one column of source data, and one column of data numbers (full page width).

Note the first line in the -----Move data from 4142 to PC-----section.

```
FOR i% = 1 to VAL(vcsteps$) + 1
```

The '+1" is needed to try to read an extra data point at the end of each sweep. This is a way to clear the EOL character from the 4142B buffer when in QuickBasic. This procedure is not needed when using HP I-BASIC.

42HPIBDO.IBW	HP 82335B, HP Instrument Basic for Windows, 4142 data output

Same as 45HPQBDO, except an enhancement has been added to the file writing routine. Code has been added to prompt the user for a file name and whether to purge any duplicate file name. I-BASIC does not automatically overwrite files, as is the case with QuickBasic.

```
'US Semiconductor Systems Center                    45HPQBBD.BAS   July 1992

'This MS-DOS QuickBasic 4.5 program uses the HP 82335B HP-IB card with
'the HP 4145B to measure the Vbe characteristics of a 2N3904 transistor.
'It uses the IBRD command to return IV data as an ASCII string array.

DECLARE SUB hp4145 (code$)              'function to send HPIB commands
Dim dev As Long                         'variable name for HP 4145B address
Rem $INCLUDE: 'QBSETUP.BAS'             'required by HP 82335B card
dev = 607                               'address of HP 4145B
Cls                                     'clear screen

Call hp4145("IT1 CA1 DR0 BC")           'IT1-short int.time, CA1-auto cal mode
                                        'DR0-data ready OFF, BC-buffer clear
Call hp4145("DE CH1,'VE','IE',3,3")     'define SMU1 as the COMMON channel
Call hp4145("CH2,'VB','IB',1,1")        'define SMU2 as Vmode and VAR1 sweep
Call hp4145("CH3;CH4;VS1;VS2;VM1;VM2")  'set all other channels to OFF
Call hp4145("SS VR1,.6,.9,.015,50E-3")  'set VAR1 0-.9v, .05steps, 50mA compl
Call hp4145("SM DM1 XN 'VB',1,.6,.9")   'set graphics mode X axis lin. 0-1v
Call hp4145("YA 'IB',1,0,50E-3")        'Y axis linear 0 to 50mA
Call hp4145("MD ME1")                   'trig single swp and display results

NOT.DONE:
Call IOSPOLL(dev, Status%)              'serial poll 4145 status
IF status% > 1 THEN GOTO NOT.DONE       'loop if 4145 is still busy
Call hp4145("DO 'IB'")                  'obtain meas data when 4145 is ready

Max.Len% = 800: actual.Len% = 0         'allocate size for data$
Data$ = Space$(Max.Len%)                'clear data$
Call IOENTERS(dev, Data$, Max.Len%, actual.Len%)    'get HP 4145B string data
LPRINT Data$                             'print all measurement values
End

Sub hp4145(code$)   'This SUB sends an HPIB command to the HP4145B
  Call IOOUTPUTS(dev, code$, Len(code$))
End Sub
```

```
'US Semiconductor Systems Center                    45NAQBBD.BAS   July 1992

'This MS-DOS QuickBasic 4.5 program uses the National PCIIA card with
'the HP 4145B to measure the Vbe characteristics of a 2N3904 transistor.
'It uses the IBRD command to return IV data as an ASCII string array.

DECLARE SUB hp4145 (code$)              'function to send HPIB commands
Dim dev%                                'variable name for HP 4145B address
Rem $INCLUDE: 'QBDECL.BAS'              'required by National PCIIA card
Call IBFIND("HP4145A", dev%)            'open device as defined in ICONF.EXE
Call IBCLR(dev%)                        'clear the 4145
Cls                                     'clear screen

Call hp4145("IT1 CA1 DR0 BC")           'IT1-short int.time, CA1-auto cal mode
                                        'DR0-data ready OFF, BC-buffer clear
Call hp4145("DE CH1,'VE','IE',3,3")     'define SMU1 as the COMMON channel
Call hp4145("CH2,'VB','IB',1,1")        'define SMU2 as Vmode and VAR1 sweep
Call hp4145("CH3;CH4;VS1;VS2;VM1;VM2")  'set all other channels to OFF
Call hp4145("SS VR1,.6,.9,.015,50E-3")  'set VAR1 .6-.9v, .015steps, 50mA comp
Call hp4145("SM DM1 XN 'VB',1,0,1")     'set graphics mode X axis lin. 0-1v
Call hp4145("YA 'IB',1,0,50E-3")        'Y axis linear 0 to 50mA
Call hp4145("MD ME1")                   'trig single swp and display results

NOT.DONE:
Call IBRSP(dev%, Status%)               'serial poll 4145 status
IF status% > 1 THEN GOTO NOT.DONE       'loop if 4145 is still busy
Call hp4145("DO 'IB'")                  'obtain meas data when 4145 is ready

Print "THIS IS THE DATA"

info$ = Space$(1100)                    'clear info$
Call IBRD(dev%, info$)                  'retrieve meas data from 4145 buffer
LPRINT info$                            'output data to printer at LPT1
End

Sub hp4145(code$)              'This SUB sends an HPIB command to the HP4145B
  Call IBWRT(dev%, code$ + Chr$(10))
End Sub
```

```
'US Semiconductor Systems Center                    45HPQBFD.BAS   July 1992

'This MS-DOS QuickBasic 4.5 program uses the HP 82335B HP-IB card with
'the HP 4145B to measure the Vbe characteristics of a 2N3904 transistor.
'It uses the IBRD command to return IV data as an ASCII string array.

DECLARE SUB hp4145 (code$)              'function to send HPIB commands
Dim dev As Long                         'variable name for HP 4145B address
Dim vb(100)                             'allocate array for Vb data
Dim ib(100)                             'allocate array for Ib data
Rem $INCLUDE: 'QBSETUP.BAS'             'required by the HP 82335B card
dev = 607                               'address of HP 4145B
Cls                                     'clear screen
Str = 0.6                               'start voltage
stp = 0.9                               'stop voltage
inc = 0.015                             'step voltage
comp = 0.05                             'current compliance
start! = Timer                          'time stamp

Call hp4145("IT1 CA1 DR0 BC")           'IT1-short int.time, CA1-auto cal mode
                                        'DR0-data ready OFF, BC-buffer clear
Call hp4145("DE CH1,'VE','IE',3,3")     'define SMU1 as the COMMON channel
Call hp4145("CH2,'VB','IB',1,1")        'define SMU2 as Vmode and VAR1 sweep
Call hp4145("CH3;CH4;VS1;VS2;VM1;VM2")  'set all other channels to OFF
Call hp4145("SS VR1," + Str$(Str))      'set VAR1 and start voltage
Call hp4145(Str$(stp) + Str$(inc))      'set VAR1 stop and step voltages
Call hp4145(Str$(comp))                 'set VAR1 current compliance
Call hp4145("SM DM1 XN 'VB',1,.6,.9")   'set graphics mode X axis lin. 0-1v
Call hp4145("YA 'IB',1,0,50E-3")        'Y axis linear 0 to 50mA
Call hp4145("MD ME1")                   'trig single swp and display results
Finish! = Timer                         'time stamp

NOT.DONE:
Call IOSPOLL(dev, Status%)              'serial poll 4145 status
IF status% > 1 THEN GOTO NOT.DONE       'loop if 4145 is still busy
Call hp4145("DO 'IB'")                  'obtain meas data when 4145 is ready
Print "No.    Vb(volts)     Ib(amps)"
vbsteps = (stp - Str) / inc + 1
Max.Len% = 13: actual.Len% = 0          'set data$ to length of 13 char.
For i% = 1 To vbsteps                   'get 4145 data one point at a time
   Data$ = Space$(Max.Len%)             'clear data$
   Call IOENTERS(dev, Data$, Max.Len%, actual.Len%)    'get next data point
   Data$ = Right$(Data$, 12)            'eliminate header char from data
   ib(i%) = Val(Data$)                  'convert Ib value to a real number
   Print USING; "##      "; i%;         'print data no.
   vb(i%) = Str + (i% - 1) * (inc)      'calculate Vb value
   Print USING; "##.###      "; vb(i%); 'print Vb value
   Print USING; "##.###^^^^"; ib(i%)    'print Ib value
Next i%

Print "Program took"; Finish! - start!;            'total elapse time
Print "seconds to make measurements."
End

Sub hp4145(code$)   'This SUB sends an HPIB command to the HP4145B
  Call IOOUTPUTS(dev, code$, Len(code$))
End Sub
```

```
'US Semiconductor Systems Center                45HPQBDO.BAS   June 1992

'This MS-DOS QuickBasic 4.5 program uses the HP 82335B HP-IB card with
'the HP 4145B to measure the Vc vs Ic characteristics of a 2N3904 transistor.
'data is printed to the screen, parallel printer, or ASCII file.  Columns of
'data include X number, X value (Vc), and Y1...Yn values (Ic at each Ib value).
'Instrument control is automatically aborted if HPIB communication fails.
'The HP 4145B is assumed to be on select code 6 at address 07.

DECLARE SUB hp4145 (code$)              'function to send HPIB commands
Dim dev As Long                         'variable name for HP 4145B address
Dim x(50)
Dim y(50, 9)                            '2-dim array for 50 data points pairs
Rem $INCLUDE: 'QBSETUP.BAS'             'required by HP 82335B card
Cls                                     'clear screen
dev = 607
ISC& = 6
timeout.Val = 3                        '3 sec. limit to send HPIB commands
Call IOTIMEOUT(ISC&, timeout.Val!)     'set flags for HPIB timeout used in the
                                       'PCIB.ERR part of SUB hp4145 (code$)

'----------------------------Set measurement parameters----------------------
vcstart$ = "0"
vcstop$ = "1"
vcstep$ = ".05"
ibstart$ = "1E-5"
ibstep$ = "1E-5"
ibsteps$ = "4"
emit$ = "1"                            'emitter   -SMU chan 1
base$ = "2"                            'base      -SMU chan 2
coll$ = "3"                            'collector -SMU chan 3
start! = Timer                         'time stamp

'----------------------------Make and display measurements-----------------
Call hp4145("IT1 CA1 DR0 BC")                    'reset (initialize)
Call hp4145("DE CH" + emit$ + ",'VE','IE',3,3")
Call hp4145("CH" + base$ + ",'VB','IB',2,2")
Call hp4145("CH" + coll$ + ",'VC','IC',1,1")
Call hp4145("CH4;VS1;VS2;VM1;VM2")
Call hp4145("SS VR1," + vcstart$ + "," + vcstop$ + "," + vcstep$ + ",50E-3")
Call hp4145("IP" + ibstart$ + "," + ibstep$ + "," + ibsteps$ + ",3")
Call hp4145("SM DM1 XN 'VC',1,0,1")
Call hp4145("YA 'IC',1,0,10E-3")
Call hp4145("MD ME1")
'----------------------------Store data in 4145 buffer---------------------
not.done:
Call IOSPOLL(dev, Status%)
IF status% <> 1 THEN GOTO not.done
Call hp4145("DO 'IC'")
finish! = Timer
'----------------------------Move 4145 data to PC--------------------------
ibsteps = Val(ibsteps$)
vcsteps = (Val(vcstop$) - Val(vcstart$)) / Val(vcstep$) + 1
Max.Len% = 13: actual.Len% = 0
For j% = 1 To ibsteps
   For i% = 1 To vcsteps
      rd$ = Space$(Max.Len%)
      Call IOENTERS(dev, rd$, Max.Len%, actual.Len%)
      rd$ = Right$(rd$, 12)
      y(i%, j%) = Val(rd$)
   Next i%
Next j%
'----------------------------Chose data output device----------------------

LINE INPUT "Send output to File <F> Printer <P> or Screen <S>: ", Output$
Close #1                                'erase old path #1 definition
Select Case UCase$(OUTPUT$)
   Case "P"
      Open "LPT1:" For Output As #1    'define path #1 as a parallel printer
      GoSub Dataprint
   Case "F"
      GoSub Datafile
   Case Else
      Open "SCRN:" For Output As #1    'define path #1 as the screen
      GoSub Dataprint
End Select
```

```
Module1 - 2

End

Dataprint: '------------------Write to screen or printer-------------------
Cls
Print #1, "No.  Vc(volts)  ";
If ibsteps > 5 Then ibsteps = 5
For i% = 1 To ibsteps - 1
  Print #1, "Ic"; LTrim$(Str$(i%)); "(amps)   ";
Next i%
  Print #1, "Ic"; LTrim$(Str$(i%)); "(amps)"
Print #1,

For i% = 1 To vcsteps
  Print #1, USING; "##    "; i%;                     'print Vc data no.
    x(i%) = Val(vcstart$) + (i% - 1) * Val(vcstep$)
    Print #1, USING; "##.##    "; x(i%);            'print Vc value
    For j% = 1 To ibsteps - 1
       Print #1, USING; "##.###^^^^  "; y(i%, j%);  'print Ic w/o carriage ret
    Next j%
       Print #1, USING; "##.###^^^^"; y(i%, ibsteps) 'print Ic with c.r.
Next i%
Print #1,
Print #1, "Program took"; finish! - start!;         'total elapse time
Print #1, "seconds to make measurements."
Return

Datafile: '-------------------------Write to file--------------------------
Open "Data.prn" For Output As #1
For i% = 1 To vcsteps
  Print #1, i%; ",";                                 'print Vc data no.
    x(i%) = Val(vcstart$) + (i% - 1) * Val(vcstep$)
    Print #1, x(i%); ",";                            'print Vc value
    For j% = 1 To ibsteps - 1
       Print #1, y(i%, j%); ",";                     'print Ic with comma del.
    Next j%
       Print #1, y(i%, ibsteps)                      'print Ic w/o comma del.
Next i%
Cls
Print "DATA.PRN was saved."
Return

Sub hp4145(code$)              'This SUB sends an HPIB command to the HP4145B
   SHARED PCIB.ERR, NOERR, PCIB.ERR$
   Call IOOUTPUTS(dev, code$, Len(code$))
   If PCIB.Err <> NOERR Then   'Check if HPIB bus is communicating
      Print PCIB.Err$          'If error, print error
      End                      'If error, terminate this program
   End If
End Sub
```

```
'US Semiconductor Systems Center                42NAQBBD.BAS   April 1992

'This MS-DOS QuickBasic 4.5 program uses the National PCIIA card with
'the HP 4142B to measure the Vbe characteristics of a 2N3904 transistor.
'It uses the IBRD command to return the entire contents of the data
'buffer as a text string.  Format is pairs of Ib and Vb data.

Rem $INCLUDE: 'QBDECL.BAS'              'required by National PCIIA card
r$ = Chr$(10)                           'decimal code for line feed character
Call IBFIND("HP4142B", hp4142%)         'open device as defined in ICONF.EXE
Call IBCLR(hp4142%)                     'clear device

Call IBWRT(hp4142%, "*RST" + r$)        'reset (initialize)
Call IBWRT(hp4142%, "FMT2,1" + r$)      'ASCII force/meas data pair format
Call IBWRT(hp4142%, "CN1" + r$)         'connect output relay on SMU in ch1
Call IBWRT(hp4142%, "WV1,1,0,.6,.9,21,.1" + r$)  '21 step linear sweep .6-.9V
Call IBWRT(hp4142%, "MM2,1" + r$)       'staircase measurement mode on ch1
Call IBWRT(hp4142%, "XE" + r$)          'trigger the measurement
Call IBWRT(hp4142%, "CL" + r$)          'disconnect all module output relays

info$ = Space$(800)                     'clear info$
Call IBRD(hp4142%, info$)               'get HP 4142B string data
LPRINT info$                            'output data to printer at LPT1
End
```

```
'US Semiconductor Systems Center                42NAQBFD.BAS   April 1992

'This MS-DOS QuickBasic 4.5 program uses the National PCIIA GP-IB card with
'the HP 4142B to measure the Vbe characteristics of a 2N3904 transistor.
'It uses the IBRD command to return Ib and Vb data as an ASCII string array.
'The HP 4142B with one SMU is assumed to be at board number (gbib0), device
'name (HP4142B), and address (02) as specified in the ICONF.EXE program.

DECLARE SUB hp4142 (code$)             'function to send GP-IB commands
Dim dev%                               'variable name for HP4142B address
Rem $INCLUDE: 'QBDECL.BAS'             'required by National PCIIA card
Call IBFIND("HP4142B", dev%)           'open device as defined in ICONF.EXE
Call IBCLR(dev%)                       'clear device
Cls                                    'clear screen
Start! = Timer                         'time stamp

Call hp4142("*RST")                    'reset (initialize)
Call hp4142("FMT2,1")                  'ASCII data format w/o header, w source
Call hp4142("CN1")                     'connect output relay on SMU in ch1
Call hp4142("WV1,1,0,.6,.9,21,.1")     '21 step linear sweep .6-.9V
Call hp4142("MM2,1")                   'staircase measurement mode on ch1
Call hp4142("XE")                      'trigger the measurement
Call hp4142("CL")                      'disconnect all module output relays


'The following routine reads back string data from the HP4142B, 26 characters
'at a time.  Format is +XX.XXXXE+XX,+XX,XXXXE+XX ordered as Ib,Vb data pairs.

Print "No.    Vb(volts)     Ib(amps)"
For i% = 1 To 21
  RD$ = Space$(26)                      'set rd$ to length of 26 characters
  Call IBRD(dev%, RD$)                  'read 26 characters from HP4142B
  VB = Val(Right$(RD$, 13))             'convert Vb value to a real number
  ib = Val(Left$(RD$, 13))              'convert Ib value to a real number
  Print USING; "##      "; i%;          'print data no.
  Print USING; "##.###      "; VB;      'print Vb value
  Print USING; "##.###^^^^"; ib         'print Ib value
Next i%

Finish! = Timer                                         'time stamp
Print "Program took"; Finish! - Start!;                'total elapse time
Print "seconds to measure and display results."

End

Sub hp4142(code$)              'This SUB sends a GPIB command to the HP4142B
  Call IBWRT(dev%, code$ + Chr$(10))     'CHR$(10) is line feed character
End Sub
```

```
'US Semiconductor Systems Center                42HPQBDO.BAS   June 1992

'This MS-DOS QuickBasic 4.5 program uses the HP 82335B HP-IB card with
'the HP 4142B to measure the Vc vs Ic characteristics of a 2N3904 transistor.
'data is printed to the screen, parallel printer, or ASCII file.  Columns of
'data include X number, X value (Vc), and Y1...Yn values (Ic at each Ib value).
'Instrument control is automatically aborted if HPIB communication fails.
'The HP 4142B with two SMUs is assumed to be on select code 6 at address 02.

DECLARE SUB hp4142 (code$)            'function to send HPIB commands
Dim dev As Long                       'variable name for HP 4142B address
Dim x(50)
Dim y(50, 9)                          '2-dim array for 50 data points pairs
Rem $INCLUDE: 'QBSETUP.BAS'           'required by HP 82335B card
Cls                                   'clear screen

'------------------------------Set measurement parameters--------------------
vcstart$ = "0"                        'sweep start voltage
vcstop$ = "1"                         'sweep stop voltage
vcsteps$ = "21"                       'number of steps in sweep
ibstart$ = "1E-5"
ibstep$ = "1E-5"
ibsteps$ = "5"                        'number of sweeps
base$ = "3"
coll$ = "2"
dev = 602                             'address of HP 4142B
ISC& = 6
timeout.Val = 2                       '2 sec. limit to send HPIB commands
Call IOTIMEOUT(ISC&, timeout.Val!)    'set flags for HPIB timeout used in the
                                      'PCIB.ERR part of SUB hp4142 (code$)

start! = Timer                        'time stamp

'--------------------------Make measurements---------------------------------
Call hp4142("*RST")                   'reset (initialize)
Call hp4142("FMT2,0")                 'ASCII format with force/meas data
Call hp4142("CN" + base$ + "," + coll$)   'connect SMU relays on base,coll.
Call hp4142("WV" + coll$ + ",1,0," + vcstart$ + "," + vcstop$ + "," + vcsteps$ + ",.1")
Call hp4142("MM2," + coll$)               'staircase measurement mode on ch1
Max.Len% = 13: actual.Len% = 0        'set rd$ to length of 13 characters
For j% = 1 To Val(ibsteps$)
   ib = Val(ibstart$) + (j% - 1) * Val(ibstep$)
   ib$ = Str$(ib)
   Call hp4142("DI" + base$ + ",0," + ib$ + ",2")
   Call hp4142("XE")                  'trigger the measurement

'--------------------------Move data from 4142 to PC-----------------------
   For i% = 1 To Val(vcsteps$) + 1    'read one extra point to clear EOL char.
      RD$ = Space$(Max.Len%)          'clear rd$
      Call IOENTERS(dev, RD$, Max.Len%, actual.Len%) 'read 13 characters
      y(i%, j%) = Val(RD$)            'convert characters to real number (Ic)
   Next i%
Next j%

Call hp4142("CL")                     'disconnect all module output relays
Finish! = Timer                       'time stamp

'----------------------------Chose data output device------------------------
vcstep = (Val(vcstop$) - Val(vcstart$)) / (Val(vcsteps$) - 1)
LINE INPUT "Send output to File <F> Printer <P> or Screen <S>: ", Output$
Close #1                              'erase old path #1 definition
Select Case UCase$(OUTPUT$)
   Case "P"
      Open "LPT1:" For Output As #1   'define path #1 as a parallel printer
      GoSub Dataprint
   Case "F"
      GoSub Datafile
   Case Else
      Open "SCRN:" For Output As #1   'define path #1 as the screen
      GoSub Dataprint
End Select

End

Dataprint: '------------------Write to screen or printer--------------------
Cls
Print #1, "No.  Vc(volts)  ";
```

```
ibsteps = Val(ibsteps$)
If ibsteps > 5 Then ibsteps = 5
For i% = 1 To ibsteps - 1
  Print #1, "Ic"; LTrim$(Str$(i%)); "(amps)   ";
Next i%
  Print #1, "Ic"; LTrim$(Str$(i%)); "(amps)"
Print #1,

For i% = 1 To Val(vcsteps$)
  Print #1, USING; "##    "; i%;                    'print Vc data no.
    x(i%) = Val(vcstart$) + (i% - 1) * vcstep
    Print #1, USING; "##.##    "; x(i%);            'print Vc value
    For j% = 1 To ibsteps - 1
      Print #1, USING; "##.###^^^^  "; y(i%, j%);   'print Ic w/o carriage ret
    Next j%
      Print #1, USING; "##.###^^^^"; y(i%, Val(ibsteps$)) 'print Ic with c.r.
Next i%
Print #1,
Print #1, "Program took"; Finish! - start!;         'total elapse time
Print #1, "seconds to make measurements."
Return

Datafile: '-------------------------Write to file--------------------------
Open "Data.prn" For Output As #1
For i% = 1 To Val(vcsteps$)
 Print #1, i%; ",";                                 'print Vc data no.
   x(i%) = Val(vcstart$) + (i% - 1) * vcstep
   Print #1, x(i%); ",";                            'print Vc value
   For j% = 1 To Val(ibsteps$) - 1
      Print #1, y(i%, j%); ",";                     'print Ic with comma del.
   Next j%
      Print #1, y(i%, Val(ibsteps$))                'print Ic w/o comma del.
Next i%
Cls
Print "DATA.PRN was saved."
Return

Sub hp4142(code$)              'This SUB sends an HPIB command to the HP4142B
   SHARED PCIB.ERR, NOERR, PCIB.ERR$
   Call IOOUTPUTS(dev, code$, Len(code$))
   If PCIB.Err <> NOERR Then   'Check if HPIB bus is communicating
      Print PCIB.Err$          'If error, print error
      End                      'If error, terminate this program
   End If
End Sub
```