Agilent 4155C
Semiconductor Parameter Analyzer
Agilent 4156C
Precision Semiconductor Parameter Analyzer

Programmer's Guide

Agilent Technologies

Notices

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Programming Overview

Agilent 4155C/4156C can be *fully* controlled from an external computer or by using built-in Instrument BASIC (IBASIC) controller. IBASIC is a programming environment that allows full control of the 4155C/4156C without using an external computer.

The 4155C/4156C has three command modes:

- *4155/4156 SCPI command mode*

  SCPI means Standard Commands for Programmable Instruments. This mode is the default mode of the 4155C/4156C, and allows you to control *all* functions of the 4155C/4156C.

- *4155/4156 FLEX command mode*

  FLEX means Fast Language for EXecution. This mode allows you to control *measurement* functions of the 4155C/4156C. Command execution is faster than the SCPI command mode.

- *4145 syntax command mode*

  This mode allows you to execute the 4145A/B programs on the 4155C/4156C directly with little or no modification. In this command mode, you *cannot* control all functions of the 4155C/4156C.

How to Migrate the 4145A/B Programs

The *4145A/B Auto Sequence Program (ASP) programs* run on the 4145A/B built-in programming environment and allow *basic* control of the 4145A/B without using an external computer. To run the ASP programs on the 4155C/4156C, you do one of the following and execute the program in the *4155/4156 SCPI command mode*:

- Create a program that performs the same operations as the desired ASP program by using the IBASIC editor typing aid softkeys to enter commands that correspond to each ASP command. This program can run on IBASIC only, *not* on an external computer. Refer to Chapter 5 for details.
- Create a program using SCPI commands that performs same operations as the desired ASP program. This program can run on IBASIC or on an external computer. Refer to "Programming Example for the 4145 Users" in Chapter 2 for details.

The *4145A/B GPIB programs* run on an external computer and allow *full* control of the 4145A/B. To run these programs on the 4155C/4156C, do one of the following:

- Directly run the 4145A/B program on the 4155C/4156C with little or no modification. You must run this program in the *4145 syntax command mode* from IBASIC or an external computer. Refer to Chapter 4 for details.
- Create a program using SCPI commands that performs same operations as the 4145A/B program. You must run this program in the *4155/4156 SCPI command mode* from IBASIC or an external computer.
- Create a program using FLEX commands that performs same operations as the 4145A/B program. You must run this program in the *4155/4156 FLEX command mode* from IBASIC or an external computer.

In This Manual

This manual describes how to control the 4155C/4156C by using GPIB commands from an external computer or built-in Instrument BASIC.

This manual consists of the following chapters:

- Using Instrument BASIC
- 4155C/4156C SCPI Command Programming
- 4155C/4156C FLEX Command Programming
- Running 4145A/B Program Directly on 4155C/4156C
- ASP-Like IBASIC Programming

Refer to *SCPI Command Reference* for SCPI commands. And refer to *GPIB Command Reference* for the FLEX commands and for the 4145 syntax commands.

See *User's Guide* and *User's Guide Measurement and Analysis* for information about the 4155C/4156C itself.

Text Conventions

The following text conventions are used in this manual:

key	Represents a key physically located on the 4155C/4156C or external keyboard.
Screen Text	Represents text that appears on screen of the 4155C/4156C.
Italic	Refers to a related document, or is used for emphasis.

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1 Using Instrument BASIC

The Instrument BASIC (IBASIC) is a system controller built into Agilent 4155C/4156C. By using IBASIC, you can run a program to control the 4155C/4156C and other instruments (connected via interfaces of the 4155C/4156C) without using an external computer.

IBASIC is a subset of HP BASIC. Programs created by IBASIC can run on an HP BASIC controller with little or no modification.

This chapter consists of the following sections.

The following sections provide step-by-step instructions to operate IBASIC by using examples. You can learn the basics of IBASIC programming and operations. If you are not familiar with IBASIC, we recommend to read through these sections first.

- Before Operating IBASIC
- Creating and Executing a Simple IBASIC Program
- Modifying Program by using Editor Functions
- Saving and Getting a Program
- Summary of Softkeys and Keyboard Operations for Editor
- Other Basic Features of IBASIC

The following sections are a task oriented reference for IBASIC. You can quickly find the desired IBASIC task.

- IBASIC Basic Operation Tasks
- IBASIC Editor Tasks
- Controlling IBASIC from External Computer

The following sections provide the reference information of IBASIC.

- IBASIC Screen
- Keys for IBASIC
- 4155C/4156C Specific IBASIC Commands
- Available I/O Resources

The following section provides the differences from the 4155A/4156A IBASIC programming.

- Differences from 4155A/4156A Programming

Before Operating IBASIC

The 4155C/4156C provides the following three screen modes for operating IBASIC.

- "All IBASIC" screen

  Entire screen including softkeys is used for IBASIC, so no instrument setup screen is displayed.

  You can execute programs, but no instrument setup screen appears in this mode.

- "IBASIC Status" screen

  Softkeys and bottom two lines are used for IBASIC. Rest of screen is for instrument setup screen.

  In this mode, you can start the IBASIC editor. The displayed softkeys are for IBASIC operation. You can execute IBASIC commands interactively. Characters you type are displayed at the bottom of the screen.

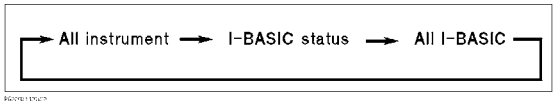
- "All Instrument" screen

  .This is regular instrument screen and the default display mode at power on. Entire screen is for instrument setup screen, and all softkeys are for interactive use of instrument. In this mode, you *cannot* use the IBASIC editor. Only the front-panel keys of IBASIC key group and **Ctrl+U** (Run) and **Ctrl+P** (Pause) on external keyboard are available to execute or pause program for the Instrument BASIC from this screen mode.

For details about the Instrument BASIC screens, refer to “IBASIC Screen” on page 1-28.

To Switch Screen Mode

To switch the screen mode, repeat one of the following instruction until the desired screen is displayed. This operation toggles screen display as shown below:



- From instrument front panel, press **Display** of IBASIC key group.
- From external keyboard, press **Ctrl+G**.

To Use the Help Function

By using the built-in help function of the 4155C/4156C, you can easily get information (name, syntax, and description) about programming commands, and can enter the desired command into the program without typing.

To start the help function for the programming commands, press **Help** key while you are in the IBASIC editor.

In the help function, the programming commands are divided into the following three categories, which you can access by secondary softkeys.

Softkey	Category
IBASIC	IBASIC commands.
PAGE IMAGE COMMAND	SCPI commands specific for the 4155C/4156C. These are the help commands associated with the instrument setup screen that begin with `:PAGE`.
SCPI COMMAND	Standard SCPI commands.

The upper part of the help screen displays a list of the command names. The lower part displays a description of the selected (by field pointer) command.

There are no Help function for the *4155/4156 FLEX command mode* and the *4145 Syntax command mode*.

To move the field pointer

To move the field pointer, refer to the following table:

Rotary knob or Arrow keys	Basically, you move the field pointer by using the rotary knob or arrow keys.
PAGE CONTROL keys	Field pointer moves to first PAGE IMAGE command that is associated with the pressed key. PAGE CONTROL keys are **Chan**, **Meas**, **Display**, **Graph/List**, **Stress**, and **System**.
MEASUREMENT keys	Field pointer moves to the PAGE IMAGE command that is associated with the pressed key. MEASUREMENT keys are **Single**, **Repeat**, and **Append**.
Get and **Save** front-panel keys	Field pointer moves to the associated SCPI command.
Alphabetical keys	Field pointer moves to next command that has a keyword that begins with same letter as the pressed key. If you are in the PAGE IMAGE command category, search is only within the instrument *screen group* of the currently selected command.

To search for a command

To search for a command:

1. Press SEARCH secondary softkey.
2. Type in command string that you want to search for, then press **Enter**

To enter a command into the editor

The command specified by the field pointer is displayed on the entry line. If you press **Enter**, the command is entered into the editor.

If command specified by the field pointer is a PAGE IMAGE or SCPI command, first select the OUTPUT @Hp415x secondary softkey. The entry line becomes `OUTPUT @Hp415x;"`*`command`*`"`, where *command* is command specified by field pointer. Then, press **Enter**.

`OUTPUT @Hp415x;"`*`command`*`"` is entered into the editor.

Creating and Executing a Simple IBASIC Program

In this section, let's try to create and execute a simple program.

Before creating a program in the IBASIC editor, first change the screen display mode to IBASIC Status screen mode or All IBASIC screen mode by pressing IBASIC **Display** key as described in "To Switch Screen Mode" on page 1-3. In following sections, the All IBASIC screen display mode is used.

1. Editing
2. Exiting from Editor
3. Executing Program

Step 1

Editing

Select EDIT secondary softkey or type `EDIT`, then press **Enter**.

```
10
```

The following program prints the numbers from 1 to 10. Type as follows:

```
10 FOR I=1 TO 10
20 PRINT I
30 NEXT I
40 END
```

NOTE

To start the editor at a specific program line or label

Type `EDIT` *linenum* or `EDIT` *label*.

For example, if you type `EDIT 30`, the cursor appears at line 30. If you do not specify a line number or label, the cursor will appear at line 10.

NOTE

Always insert mode

Editor is always in insert mode, and *cannot* be changed to overwrite mode. If you typed wrong characters, use **Backspace** to move back a character, or move cursor using ⇐ key, then use **Delete** to delete a character. Then type correct characters.

NOTE

Program End

In IBASIC, `END` must be at end of main program. In above example, line 40 is the last line of the program.

Step 2

Exiting from Editor

Select the End edit primary softkey to exit from the editor.

Step 3

Executing Program

To execute the program, press **Run** of the IBASIC key group, select RUN primary softkey, or type RUN and press **Enter**. The following should be displayed on the screen:

```
1
2
3
4
5
6
7
8
9
10
```

NOTE

If an error message appears

If an error message appears, you probably typed wrong characters. The error message indicates the line number where the error occurs. You need to modify the line.

Modifying Program by using Editor Functions

In this section, you can learn the following editor functions:

1. Inserting lines
2. Deleting a line
3. Renumbering
4. Inserting characters
5. Recalling deleted line
6. Indenting

Step 1 **Inserting Lines**

Type `EDIT 20`, then press **Enter**. Cursor appears at line 20.

```
10 FOR I=1 TO 10
20 PRINT I
30 NEXT I
40 END
```

Select Insert line or press **Insert** to insert a line above line 20.

```
10 FOR I=1 TO 10
11
20 PRINT I
30 NEXT I
40 END
```

Type as follows:

```
10 FOR I=1 TO 10
11 PRINT I^2
20 PRINT I
30 NEXT I
40 END
```

`I^2` means the second power of I. The above program increments `I` from 1 to 10, and displays second power of I and I for each step.

Select End edit to exit editor, then press **Run** to execute the program. The following is displayed:

```
1
1
4
2
9
3
:
:
81
9
100
10
```

Step 2 **Deleting a Line**

Type `EDIT 20` to start editor at line 20.

```
10 FOR I=1 TO 10
11 PRINT I^2
20 PRINT I
30 NEXT I
40 END
```

Then, select Delete line or press **Shift+Delete** to delete line 20. The result is as follows:

```
10 FOR I=1 TO 10
11 PRINT I^2
30 NEXT I
40 END
```

The above program increments `I` from 1 to 10, and displays the second power of I at each step.

If you exit editor and execute the program, the following is displayed:

```
1
4
9
:
:
81
100
```

Step 3 **Renumbering**

In above example, line numbers are not in equal increments. To change the line number increment to 10, select Re-number softkey. Line numbers will be changed as follows:

```
10 FOR I=1 TO 10
20 PRINT I^2
30 NEXT I
40 END
```

If you use the Re-number softkey, the renumbering is always as follows: first line is 10 and the increment is 10.

If you desire other numbering, you need to exit the editor, and use the `REN` command. For example, if you want first line number to be 100 and increment to be 20, type as follows:

`REN 100, 20` **Enter**

Step 4 **Inserting Characters**

Type `EDIT 20`, then press **Enter**.

```
10 FOR I=1 TO 10
20 PRINT I^2
30 NEXT I
40 END
```

Move the cursor by using right key.

```
10 FOR I=1 TO 10
20 PRINT I^2
30 NEXT I
40 END
```

Then type `I,` as follows:

```
10 FOR I=1 TO 10
20 PRINT I,I^2
30 NEXT I
40 END
```

Above program increments `I` from 1 to 10, and displays I and the second power of I on one line at each step. Exit editor, then execute the program. The following is displayed:

```
1             1
2             4
3             9
:             :
:             :
9             81
10            100
```

Step 5 **Recalling Deleted Line**

To restore the most recently deleted line, press **Recall** front-panel key.

Step 6 **Indenting**

Move to desired line, then select Indent to indent the line. Indenting makes the program flow easier to understand.

```
10 FOR I=1 TO 10
20    PRINT I,I^2
30 NEXT I
40 END
```

Saving and Getting a Program

The created program can be saved to a diskette. So, you can get the saved program from the diskette, then execute it.

In this section, you can learn the following file operation tasks:

1. Saving a Program
2. Listing Contents of Diskette
3. Clearing a Program
4. Getting a Program

Step 1

Saving a Program

Insert a diskette into the built-in flexible disk drive. Then, type `SAVE "`*filename*`"`, then press **Enter**. For this example, we will type `SAVE "PROG1"`.

Step 2

Listing Contents of Diskette

Type `CAT` to list contents of the diskette.

If you are using an MS-DOS format diskette, the display is similar to the following example:

```
DIRECTORY : \:INTERNAL,4
LABEL: 4156
FORMAT: DOS
AVAILABLE SPACE :      5692
                 FILE     NUM   REC     MODIFIED
FILE NAME        TYPE    RECS   LEN    DATE    TIME PERMISSION
============ ====== ======= ===== ========= ===== ==========
PROG1        DOS         65     1 27-Jun-94 14:30 RW-RW-RW-
```

You can also check the contents of the diskette by using the filer (SYSTEM: FILER screen) of the 4155C/4156C. But you *cannot* save and get the IBASIC programs by using the filer.

Step 3

Clearing a Program

To clear the program, enter the editor, then select Scratch softkey. Then, select Yes secondary softkey.

Existing program will be cleared, and following is displayed:

```
10 COM @Hp415x
20 ASSIGN @Hp415x TO 800
30!
9990 END
```

`COM @Hp415x` and `ASSIGN @Hp415x TO 800` are used to control the 4155C/4156C as follows.

- `COM @Hp415x`

  Declares COM so that subprograms can access the I/O path (that is assigned in line 20) for controlling the 4155C/56C. Refer to the *Instrument BASIC Users Handbook* for details.

- `ASSIGN @Hp415x TO 800`

  Assigns the I/O path for controlling the 4155C/56C. `800` means built-in IBASIC controller.

Refer to “Subprograms and COM Blocks” on page 1-16.

NOTE

To ASSIGN I/O path

- Built-in IBASIC controller

  Specify select code 8. For the GPIB address, you can use *any* number between 0 to 31. Refer to the following example:

  ```
  10 ASSIGN @Hp4155 TO 800
  ```

- HP BASIC on an external computer

  Specify the select code of the external computer. And specify the GPIB address that you entered into the GPIB ADDRESS field on the SYSTEM: MISCELLANEOUS screen. In the following example, the select code of the external computer is 7 and GPIB address of the 4155C/4156C is 17:

  ```
  10 ASSIGN @Hp4155 TO 717
  ```

Step 4

Getting a Program

Type `GET "PROG1"`, then press **Enter**. When the LED turns off, enter the editor if you want to display the program.

Summary of Softkeys and Keyboard Operations for Editor

Front-panel keys

Arrow keys	Move the cursor
Delete	Delete character
Recall	Recall most recently deleted line

External Keyboard

Esc	Exit editor
F1 to **F8**	Primary softkeys
Shift+ F1 to **F7**	Secondary softkeys
F9	Toggle screen mode
F11	Clear to end
Insert	Insert line
Delete	Delete character at cursor
Shift+Delete	Delete line
Home	Beginning of line
End	End of line
Page Up or **Page Down**	Scroll pages

Primary Softkeys

Back space	Delete character before cursor
Insert line	Insert line
Delete line	Delete line
Re-number	Renumber the lines
Indent	Indent the line
Scratch	Clear program
End edit	Exit editor

Other Basic Features of IBASIC

This section describes the following:

- Branching/Repeating
- Subprograms and COM Blocks

Branching/Repeating

Branch and Repeat Keywords of IBASIC are shown in the following table:

IBASIC Keyword	Function
`FOR, NEXT`	Repeat specified number of times.
`IF THEN, ELSE, END IF`	Branch.
`WHILE, END WHILE`	Repeat until specified condition is *false*.
`REPEAT, UNTIL`	Repeat until specified condition is *true*.

Following program tests 1000 devices, and judges them pass or fail.

```
1   COM Data(1:1000)
2   DIM Id(1:1000)
10  EXECUTE ("GETSETUP 'SAMPL.MES'")
20  FOR I=1 TO 1000
30     EXECUTE ("SINGLE")
40     EXECUTE ("READDATAVAR'Id'")
50     IF Id(I)<1E-6 THEN
60        PRINT "FAIL LOWER"
70        Data(I)=1
80     ELSE
90        IF Id(I)>1E-4 THEN
100          PRINT "FAIL HIGHER"
110          Data(I)=2
120       ELSE
130          PRINT "PASS"
140          Data(I)=0
150       END IF
160    END IF
170 NEXT I
180 CALL Save_data
190 END
200!
210 SUB Save_data
220 COM Data(*)
230 CREATE "data_file",1
240 ASSIGN @File TO "data_file";FORMAT ON
250 OUTPUT @File;Data(*)
260 ASSIGN @File TO *
270 SUBEND
```

Subprograms and COM Blocks

One of the most powerful constructs available is the subprogram. A subprogram has its own "context" or state that is distinct from the main program and all other subprograms. There are several benefits of subprograms.

- The subprogram allows you to take advantage of the "top-down design" method of programming.
- You can remove all subtasks from the overall logic flow of the main program.
- You can debug the program by testing each subprogram independently.
- The subprograms can be used to reduce the overall size of the program.
- Libraries of commonly used subprograms can be assembled for widespread use.

Refer to the example program in the previous section. Line 180 calls a subprogram to store data into a DOS file.

```
:
:
160    END IF
170 NEXT I
180 CALL Save_data
190 END
200!
210 SUB Save_data
220 COM Data(*)
230 CREATE "data_file",1
240 ASSIGN @File TO "data_file";FORMAT ON
250 OUTPUT @File;Data(*)
260 ASSIGN @File TO *
270 SUBEND
```

COM blocks

COM blocks are used by the subprogram to communicate with the main program or with other subprograms.

If you create subprograms and want to use common variables between main program and subprograms, you should use COM blocks.

Refer to the above example.

In the main program, line 1 declares that the `Data` array will be a COM array. Then, the main program assigns values to this array. Line 220 specifies that the subprogram `Save_data` will also use the `Data` array. So, `Data` array of main program can be operated on in the `Save_data` subprogram.

IBASIC Basic Operation Tasks

This section describes the following basic operations to use the Instrument BASIC.

1. Executing the Instrument BASIC commands
2. Executing program
3. Listing files
4. Retrieving program
5. Saving program

Step 1 **Executing the Instrument BASIC Commands**

1. Confirm your 4155C/4156C is in the following status:
   - a program is not executing.
   - another command is not executing.
   - Editor is not running.
   - the screen is "All IBASIC" screen or "IBASIC Status" screen. For "All Instrument" screen, **Run** and **Pause** front-panel keys and **Ctrl+U** (Run) and **Ctrl+P** (Pause) on external keyboard are available.
2. Type in commands by using front-panel keys in the ENTRY key group or external keyboard.
3. Press **Enter** front-panel key or **Enter** key on external keyboard.

Step 2 **Executing Program**

To execute the program, perform one of the following instruction:

- From instrument front panel, press **Run** front-panel key in the IBASIC key group.
- From external keyboard, press **Ctrl+U** on external keyboard.

Step 3 **Listing Files**

1. Confirm your 4155C/4156C is in the following status:
   - the screen is "All IBASIC" screen.
   - a program is not executing.
   - another command is not executing.
   - Editor is not running.
2. Insert a 3.5 inch diskette (that contains the files you want to list) into the built-in flexible disk drive.
3. Select CAT secondary softkey, then press **Enter** front-panel key.

The file names on diskette are listed on the screen.

Step 4 **Retrieving Program**

1. Confirm your 4155C/4156C is in the following status:
   - the screen is "All IBASIC" screen or "IBASIC Status" screen.
   - a program is not executing.
   - another command is not executing.
   - Editor is not running.
2. Insert the 3.5 inch diskette (that contains the program you want to retrieve) into the built-in flexible disk drive.
3. Select GET "" secondary softkey.
4. Type in file name to be retrieved. Typed name is inserted after first **"**.
5. Press **Enter** front-panel key, or **Enter** key on external keyboard.

NOTE **External disk drive**

An external disk drive cannot be connected to the 4155C/4156C. For using a disk drive connected to external controller, see “Controlling IBASIC from External Computer” on page 1-24.

Step 5 **Saving Program**

1. Confirm your 4155C/4156C is in the following status:
   - the screen is "All IBASIC" screen or "IBASIC Status" screen.
   - a program is not executing.
   - another command is not executing.
   - Editor is not running.
2. Insert a 3.5 inch diskette into the built-in flexible disk drive.
3. Select SAVE "" secondary softkey.
4. Type in name of file to which you want to save program.

   If the file already exists on the diskette, SAVE cannot be used. If you want to overwrite an existing file, select RE-SAVE secondary softkey instead of SAVE secondary softkey in the previous step.
5. Press **Enter** front-panel key or **Enter** key on the external keyboard.

NOTE **External disk drive**

An external disk drive cannot be connected to the 4155C/4156C. For using a disk drive connected to external controller, see “Controlling IBASIC from External Computer” on page 1-24.

IBASIC Editor Tasks

This section describes the following tasks to use built-in editor of the Instrument BASIC.

1. Starting the editor
2. Quitting the editor
3. Moving the cursor
4. Inserting characters
5. Deleting character
6. Inserting line
7. Deleting line
8. Scrolling pages
9. Recalling most recently deleted line

Step 1

Starting the Editor

1. Confirm the screen is "All IBASIC" screen or "IBASIC Status" screen.
2. Select EDIT secondary softkey.
3. Press **Enter** front-panel key or **Enter** key on the external keyboard.

   If you want to start the editor to edit a specific program line, type in the line number or label of the program line, then press **Enter** front-panel key. The editor starts, and cursor is displayed on specified line.
4. If a program is loaded into the 4155C/4156C, the program is displayed.

   If no program is loaded, `10` is automatically displayed and rest of screen is empty.

If you start the editor from the "IBASIC Status" screen, the screen switches to "All IBASIC" screen, and the editor starts.

Step 2

Quitting the Editor

- Select End edit primary softkey.

If you started the editor from the "IBASIC Status" screen, the screen returns from "All IBASIC" screen to the "IBASIC Status" screen after you quit the editor.

Step 3 **Moving the Cursor**

- To move the cursor, use the following keys.

Direction	Front-panel	Keyboard
Up	⇑ key of MARKER/CURSOR group	⇑ key
	Rotate rotary knob counter-clockwise	
Down	⇓ key of MARKER/CURSOR group	⇓ key
	Rotate rotary knob clockwise	
Right	⇒ key of ENTRY group	⇒ key
	⇒ key of MARKER/CURSOR group	**Ctrl+F**
Left	⇐ key of ENTRY group	⇐ key
	⇐ key of MARKER/CURSOR group	**Ctrl+B**
Beginning of Line	**FAST**+ ⇐ of MARKER/CURSOR group	**Home**
		Shift+ ⇐
End of Line	**FAST**+ ⇒ of MARKER/CURSOR group	**End**
		Shift+ ⇒

Step 4 **Inserting Characters**

1. Move the cursor to character you want to insert before.
2. Characters you type will be automatically inserted.
3. After you insert characters, you must select the **Enter** key to enter the line with inserted characters into the program.

Editor is always in insert mode, and cannot be changed to overwrite mode.

Step 5 Deleting Character

1. Move the cursor to character you want to delete.
2. Press key according to the following table:

Front-panel	Keyboard
Delete of ENTRY group	**Delete**

3. After you delete characters, you must select the **Enter** key to enter the line with deleted characters into the program.

Step 6 Inserting Line

1. Move the cursor to the line that you want to insert a new line before.
2. Press key or softkey according to following table:

Front-panel	Keyboard
Insert line primary softkey	**Shift+Insert**
	Alt+I

3. After you type in a new line, you must select the **Enter** key to enter the new line into the program.

Step 7 Deleting Line

1. Move the cursor to line you want to delete.
2. Press key or softkey according to the following table:

Front-panel	Keyboard
Delete line primary softkey	**Shift+Delete**
	Alt+D

Step 8 **Scrolling Pages**

- To scroll the editor by one-half screen, use the following keys:

Direction	Front-panel	Keyboard
Up	n.a.	**Page Up**
Down	n.a.	**Page Down**

Step 9 **Recalling Most Recently Deleted Line**

- To display the line most recently deleted line, use the following keys.

Front-panel	Keyboard
Recall↓	**Shift+Page Up**

If you want to enter the line into the program, you must select the **Enter** key.

Controlling IBASIC from External Computer

This section describes how to control the IBASIC program on the 4155C/4156C from a program that is running on an external computer:

- Controlling execution of a 4155C/4156C program.
- Downloading a program to the 4155C/4156C.
- Uploading a program from the 4155C/4156C.

Before executing a program on external computer to control the 4155C/4156C, do as follows:

1. Connect an GPIB cable from the external computer to the GPIB connector on rear panel of the 4155C/4156C.
2. Set the "`4155C/4156C is`" field on the SYSTEM: MISCELLANEOUS screen to NOT SYSTEM CONTROLLER.
3. Enter the GPIB address of your 4155C/4156C into the `GPIB ADDRESS` field.

Step 1

To Control State of the 4155C/4156C Program

:PROGram[:SELected]:STATe command from external computer can control the Instrument BASIC program in the 4155C/4156C as follows:

- To run the program:

```
OUTPUT @Hp4155;":PROGram[:SELected]:STATe RUN"
```

- To continue the program:

```
OUTPUT @Hp4155;":PROGram[:SELected]:STATe CONT"
```

- To stop the program:

```
OUTPUT @Hp4155;":PROGram[:SELected]:STATe STOP"
```

- To pause the program:

```
OUTPUT @Hp4155;":PROGram[:SELected]:STATe PAUSE"
```

Step 2

To Download a Program to the 4155C/4156C

To download a program from the external computer to the 4155C/4156C, you need to use the :PROGram[:SELected]:DEFine command.

The following is an example of an HP BASIC program (running on external computer) that reads an Instrument BASIC program file (ASCII file stored in a disk drive connected to external computer) and downloads it to the 4156C.

```
10    OPTION BASE 1
20    !
30    DIM Line$[1024]
40    !
50    ASSIGN @Hp4156 TO 717
60    !
70    OUTPUT @Hp4156;":PROG:DEL:ALL" !Clears program in 4156C
80    File_name$="prog"
90    ASSIGN @File TO File_name$      !Opens file and assigns dat
a path
100   OUTPUT @Hp4156;":PROG:DEF #0"  !Sends header to 4156C
110   ON ERROR GOTO Done
120   LOOP
130     Line$=""
140     ENTER @File;Line$            !Reads one program line
150     OUTPUT @Hp4156;Line$         !Downloads line to 4156C
160   END LOOP
170 Done:!
180   OFF ERROR
190   OUTPUT @Hp4156;Line$
200   OUTPUT @Hp4156;" " END
210   ASSIGN @File TO *
220   END
```

Line Number	Description
50	assigns I/O path to control the 4155C/4156C.
70	deletes existing the Instrument BASIC program in the 4155C/4156C.
80	name of file (in disk drive of external computer) that contains desired the Instrument BASIC program
90	opens file and assigns data path
100	#0 indicates that an indefinite length of parameters (program lines) will be downloaded
110 to 160	reads program lines from the file and downloads them until EOF.
210	closes file.

Step 3 **To Upload a Program from the 4155C/4156C**

To upload a program from the 4155C/4156C to external computer, you need to use the :PROGram[:SELected]:DEFine? command.

The following is an example of an HP BASIC program (running on external computer) that uploads an Instrument BASIC program (ASCII file) from the 4156C and stores the program on a disk drive that is connected to external computer.

```
10    OPTION BASE 1
20    !
30    DIM Num_dig$[2]
40    INTEGER Byte
50    !
60    ASSIGN @Hp4156 TO 717
70    !
80    OUTPUT @Hp4156;":PROG:DEF?"
90    ENTER @Hp4156 USING "%,2A";Num_dig$
100   PRINT Num_dig$
110   !
120   Byte=VAL(Num_dig$[2])
130   !
140   ALLOCATE Data_byt$[Byte]
150   !
160   FOR I=1 TO Byte
170   ENTER @Hp4156 USING "#,A";Data_byt$[I;1] !Enter length of p
rogram
180   NEXT I
190   !
200   D=VAL(Data_byt$)
210   PRINT D
220   ALLOCATE Prog$[D]
230   PRINTER IS CRT;WIDTH D
240   ENTER @Hp4156 USING "-K";Prog$           !Enter the program
 into Prog$
250   PRINT Prog$
260   ENTER @Hp4156;B$
270   PRINT B$
280   !
290   CREATE "prog",1
300   ASSIGN @File TO "prog";FORMAT ON
310   OUTPUT @File;Prog$
320   ASSIGN @File TO *
330   !
340   END
```

Line Number	Description
60	Assigns I/O path to control the 4155C/4156C.
80	Sends :PROGram[:SELected]:DEFine? query command.
90	Reads first two characters of response. These two bytes indicate how many bytes are used to specify length of program.
160 to 180	Reads the bytes that specify length of program.
200	Calculates length of program.
220	Allocates string variables for program.
240	Reads program.
260	Reads terminator.
290	Creates file "prog"
300	Assigns I/O path to "prog"
310	Stores program into "prog" file.
320	Closes file.

IBASIC Screen

The 4155C/4156C provides the following three screen modes for operating IBASIC.

- "All IBASIC" screen

  Entire screen including softkeys is used for IBASIC, so no instrument setup screen is displayed.

  You can execute programs, but no instrument setup screen appears in this mode.

- "IBASIC Status" screen

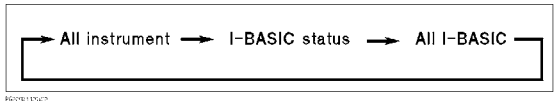
  Softkeys and bottom two lines are used for IBASIC. Rest of screen is for instrument setup screen.

  In this mode, you can start the IBASIC editor. The displayed softkeys are for IBASIC operation. You can execute IBASIC commands interactively. Characters you type are displayed at the bottom of the screen.

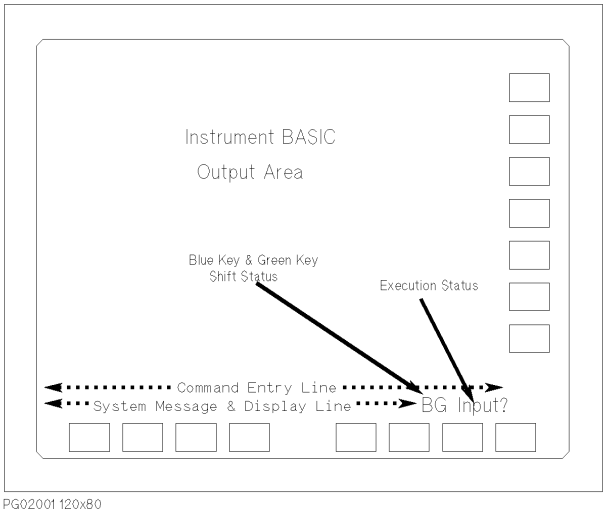
- "All Instrument" screen

  .This is regular instrument screen and the default display mode at power on. Entire screen is for instrument setup screen, and all softkeys are for interactive use of instrument. In this mode, you *cannot* use the IBASIC editor. Only the front-panel keys of IBASIC key group and **Ctrl+U** (Run) and **Ctrl+P** (Pause) on external keyboard are available to execute or pause program for IBASIC from this screen mode.

Display front-panel key or **Ctrl+G** (or **F9**) on external keyboard are used to toggle the screen display mode as shown in the following figure:



All IBASIC Screen



For the "All IBASIC" screen, the entire screen including softkeys is used for IBASIC. The following describes each part of this screen:

IBASIC Output Area

Screen output commands of IBASIC (such as `PRINT` and `OUTPUT 1;`) display characters in this area. This area has 23 lines and 58 columns (58 characters in a line).

Command Entry Line

IBASIC command you type is displayed on this line. The length of this line is 58 characters.

System Message and Display Line

For displaying IBASIC error messages and other system messages, and `DISP` and `INPUT` commands of IBASIC.

Execution Status

This field displays the execution status of IBASIC:

`Idle` IBASIC program is stopped. IBASIC commands can be executed.

`Run` IBASIC program or command is being executed.

`Pause` IBASIC program is paused.

`Input?` IBASIC program is waiting for input from front-panel keys or external keyboard.

`Edit` IBASIC editor is running.

Blue Key & Green Key Shift Status

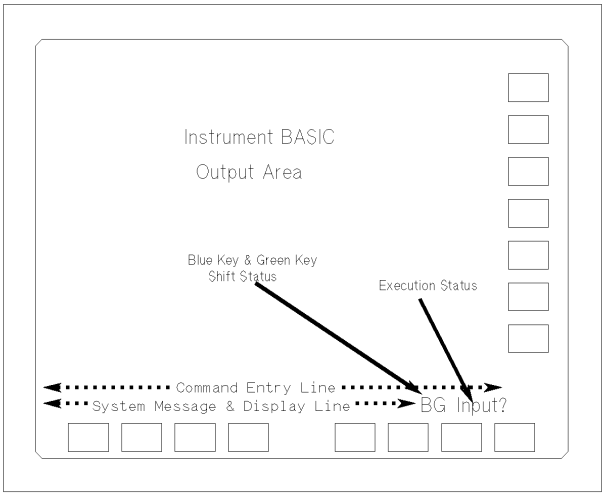
This field displays the shift status of ENTRY front-panel keys. The shift status is controlled by using the blue and green front-panel keys:

The following statuses are displayed:

- Non-shift status: `B`, `b`, or `G` is not displayed. You can enter numeric values.
- Uppercase shift status: `B` is displayed, `G` is not displayed. You can enter uppercase alphabet characters.
- Lowercase shift status: `b` is displayed. `G` is not displayed. You can enter lowercase alphabet characters.
- Non-alphanumeric status: `G` is displayed. You can enter one non-alphanumeric character. So, you must press green key before entering each alphanumeric character.

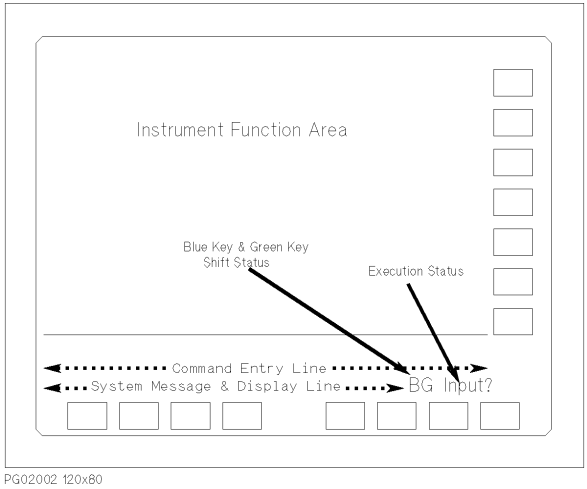
Basically, you can change between these states as follows:

- To toggle between non-shift and shift status: press blue key,
- To toggle between uppercase and lowercase shift status: press green key, then blue key.
- To enter one non-alphanumeric character: press green key, then character.



PG02001 120x80

IBASIC Status Screen



For the "IBASIC Status" screen, the two bottom lines are used to display the status of IBASIC. These two lines are the same as in "All IBASIC" screen. Refer to “All IBASIC Screen” on page 1-29. Also, the softkeys are for IBASIC.

The other part of the screen is the normal 4155C/4156C screen. This is useful if you want to view a graph of the measurement results while executing IBASIC program.

Keys for IBASIC

This section provides information about the following keys for IBASIC:

- Front-panel Keys
- Primary Softkeys
- Secondary Softkeys
- External Keyboard Keys

Front-panel Keys for IBASIC

PAGE CONTROL key group

- In "IBASIC Status" screen:

  Changes to "All Instrument" screen and displays the specified screen.

- In "All IBASIC" screen:

  All front-panel keys in this group are *ignored*.

MARKER/CURSOR key group

- In "IBASIC Status" screen:

  When you operate MARKER/CURSOR front-panel keys, the screen changes to "All Instrument" screen and function of operated key is executed.

- In all IBASIC screen:

Rotary Knob	When the editor is running, the rotary knob moves the cursor vertically in the edit area. When the editor is not running, the rotary knob scrolls the IBASIC output area.
⇑, ⇓	When the editor is running, these keys move the cursor vertically. When the editor is not running, these keys scroll the IBASIC output area.
⇐, ⇒	Moves the cursor horizontally on the IBASIC Editor or Command Entry line.

If you hold down the **Fast** key, the arrow keys move the cursor faster.

MEASUREMENT key group

- In "IBASIC Status" screen:

Single, Repeat,Append	Changes the display to GRAPH/LIST: GRAPHICS or GRAPH/LIST: LIST screen and executes the measurement.
Standby	Toggles the operation state of the standby channels between the standby state and the idle state.
Stop	Stops the measurement or stress forcing.
Stress	Changes the display to the STRESS: STRESS FORCE screen and starts to force stress.
Short, Medium,Long	Changes the measurement integration time.

- In "All IBASIC" screen:

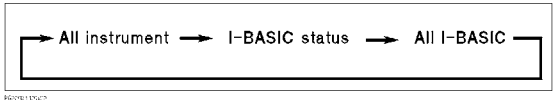
Standby	Toggles the operation state of the standby channels between the standby state and the idle state.
Stop	Stops the measurement or stress forcing.

Other front-panel keys in this group are ignored.

IBASIC key group

The following front-panel keys of IBASIC key group are available to control IBASIC in any display mode.

Run	Executes IBASIC program that is loaded into internal memory of the 4155C/4156C.
Pause	Pauses program execution until CONT command is executed or Continue primary softkey is pressed. If the program is modified while paused, RUN command must be used to restart program execution.
Display	Toggles the display mode in the following sequence.



ENTRY key group

Recall↓

- When the editor is running, this key displays the last deleted line. To enter this displayed line as part of the program, press **Enter** front-panel key.
- When the editor is not running, this key cycles through the 10 commands that were most recently entered on the Command Entry line.

Recall↑

- When the editor is running, this key is same as **Recall↓**.
- When the editor is not running, this key is same as **Recall↓**, but cycles through commands in opposite order.

Save, Get These keys are ignored.

Other front-panel keys in ENTRY group are available to enter characters on the Command Entry line or Editor. For the usage of the blue and green front-panel keys to enter characters, see “All IBASIC Screen” on page 1-29.

Other Keys

Help Displays information about IBASIC. And can be used to select and enter SCPI and IBASIC commands into Editor or Command Entry line.

Plot/Print If present screen is "All IBASIC", dumps "All IBASIC" screen image to the printer or plotter.

If present screen is "IBASIC Status", prints/plots instrument part of screen.

Primary Softkeys in Idle, Pause, Run, or Input? execution status

This section describes the primary softkeys that are displayed during the `Idle`, `Pause`, `Run`, or `Input?` execution status.

Refer to "Primary Softkeys in Edit execution status" on page 1-37 for primary softkeys that are displayed when the editor is running.

Step

1. Executes the paused program line of paused program or the first program line of stopped (idle) program.
2. Displays next program line on system message line of the screen.
3. Pauses program again.

Conti-nue

Starts execution of paused program from paused program line.

RUN

Starts program execution immediately from first program line.

Pause

Pauses program execution immediately. And displays line at which execution was paused.

Stop

Stops program execution after current line executes.

Clear I/O

Stops I/O operation of program.

Reset

Stops program execution immediately.

Secondary Softkeys in Idle or Pause execution status

This section describes the secondary softkeys that are displayed during the `Idle` or `Pause` execution status.

For the secondary softkeys that are displayed during the `Run` or `Input?` status, refer to “Secondary Softkeys in Run or Input? execution status” on page 1-37.

For the secondary softkeys that are displayed when the editor is running, refer to “Secondary Softkeys in Edit execution status” on page 1-38.

CAT

Clears the Command Entry line, and types in `CAT`.

To list file names on the diskette, press **Enter**.

SAVE ""

1. Clears the Command Entry line.
2. Types in `SAVE " "`.
3. Positions the cursor after first `"`.

To save program to diskette, type name of file to which you want to save program, then press **Enter**.

If file already exists on diskette, program will not be saved.

RE-SAVE ""

1. Clears the Command Entry line.
2. Types in `RE-SAVE " "`.
3. Positions the cursor after first `"`.

To save program to diskette, type name of file to which you want to save program, then press **Enter**.

If file already exists on diskette, file will be overwritten, so previous data in file is lost.

GET ""

1. Clears the Command Entry line.
2. Types in `GET " "`.
3. Positions the cursor after first `"`.

To get a program from diskette, type name of file to get, then press **Enter**.

PURGE ""

1. Clears the Command Entry line.
2. Types in `PURGE " "`.
3. Positions the cursor after first `"`.

To delete a file from diskette, type in the file name to be deleted, then press **Enter**.

EDIT

Clears the Command Entry line and types in `EDIT`. To start the editor, press **Enter** front-panel key.

REN umber

Clears the Command Entry line and types in `REN`.

To re-number lines of a program, type in appropriate parameters, then press **Enter**. For more details about `REN` command, refer to the *Instrument BASIC User's Handbook*.

Secondary Softkeys in Run or Input? execution status

When the execution status is `Run` or `Input?`, user-defined softkeys, which are defined by using `ON KEY` command in the program, are displayed in the secondary softkey area.

Primary Softkeys in Edit execution status

This section describes the primary softkeys that are displayed when the IBASIC editor is running (`Edit` execution status is displayed).

Back space

Deletes the character before the cursor.

Insert line

Inserts a line between the cursor line and the previous line.

Delete line

Deletes the cursor line.

Re-number

Changes the program line numbers so that first line is 10 and line number increment is 10.

Indent

Indents so that all program lines begin at the same position.

Scratch

Clears the program and all variables not in COM. Before clearing, YES and NO secondary softkeys are displayed for confirmation.

End edit

Exits the editor.

Secondary Softkeys in Edit execution status

This section describes the secondary softkeys that are displayed when the IBASIC editor is running (`Edit` execution status is displayed).

These softkeys help you enter program commands. For commands that require you to type in some parameters, these softkeys display the command. You must enter the parameters, then you must press **Enter** key to enter the command into the program. For commands that do not have parameters, the commands are entered directly into the program. Commands are entered at the cursor line.

For the EXECUTE command, refer to "EXECUTE" in Chapter 5 for details.

For secondary softkeys that are displayed during `Idle` or `Pause` execution status, refer to "Secondary Softkeys in Idle or Pause execution status" on page 1-36.

For secondary softkeys that are displayed during `Run` or `Input?` execution status, refer to "Secondary Softkeys in Run or Input? execution status" on page 1-37.

In `Edit` execution status, there are three kinds of secondary softkey menu. To move to next menu, press MORE secondary softkey.

GET SETUP

1. Displays the following program line for loading a setup file:

   ```
   EXECUTE("GETSETUP ")
   ```

2. Positions cursor at second double quotes. You enter the file name to be loaded, then select **Enter** key.

SINGLE

Enters the following program line for triggering a single measurement:

```
EXECUTE("SINGLE")
```

STANDBY

1. Displays the following program line for changing the operation state of the standby channels:

   ```
   EXECUTE("STANDBY ")
   ```

2. Positions the cursor at the second double quote. You enter `ON` or `OFF`, then select **Enter** key.

STRESS

Enters the following program line for triggering stress force:

```
EXECUTE("STRESS")
```

AUTO SCALE

Enters the following program line for autoscaling:

```
EXECUTE("AUTOSCALE")
```

SAVE DATA

1. Displays the following program line for saving measurement data to a file:

   ```
   EXECUTE("SAVEDATA ")
   ```

2. Positions the cursor at the second double quote. You enter file name to which you want to save measurement data, then select **Enter** key.

READ DATA VARIABL

1. Displays the following program line for reading the values of an 4155C/4156C data variable, then storing the values into an IBASIC program variable:

   ```
   EXECUTE("READDATAVAR ,")
   ```

2. Positions the cursor at the comma. You enter names of the 4155C/4156C data variable and IBASIC program variable, then select **Enter** key.

DEFINE USER VARIABL

1. Displays the following program line for defining a user variable:

   ```
   EXECUTE("DEFUSERVAR ,,,")
   ```

2. Positions the cursor at the first comma. You enter the user variable name, number of data, name of IBASIC program variable that contains desired data, and user variable unit, then select **Enter** key.

PRINT/PLOT

Enters following program line for printing/plotting the instrument window:

```
EXECUTE("PRINTPLOT")
```

CURVE PLOT

Enters following program line for printing/plotting a graphics plot of measurement results:

```
EXECUTE("CURVEPLOT")
```

OUTPUT @Hp415x

1. Displays the following program line for outputting a command to the 4155C/4156C:

   ```
   OUTPUT @Hp415x;""
   ```

2. Positions the cursor at the second double quotes. You enter desired command, then select **Enter** key.

ENTER @Hp415x

1. Displays the following program line for entering data from the 4155C/4156C:

   ```
   ENTER @Hp415x;
   ```

2. Positions the cursor after the semicolon. You enter desired variable, then select **Enter** key.

PAUSE

Enters the following program line for pausing a program:

```
PAUSE
```

DISP

1. Displays the following program line for displaying a message:

   ```
   DISP ""
   ```

2. Positions the cursor at the second double quotes. You enter the message that you want to display, then select **Enter** key.

INPUT

1. Displays the following program line for assigning keyboard input to program variable:

   ```
   INPUT "",
   ```

2. Positions the cursor at the second double quote. Enter string that you want to be displayed on the screen, and name of variable in which you want to store keyboard input, then select **Enter** key.

IF THEN ELSE END IF

1. Displays the following program lines for conditional branching:

   ```
   IF  THEN
   ELSE
   END IF
   ```

2. Positions the cursor before `THEN`. Fill in as desired, then select **Enter** key.

WHILE END WHILE

1. Displays the following program lines for defining a loop:

   ```
   WHILE
   END WHILE
   ```

2. Positions the cursor after `WHILE`. Fill in as desired, then select **Enter** key.

FOR NEXT

1. Displays the following program lines for defining a loop:

   ```
   FOR = TO  STEP
   NEXT
   ```

2. Positions the cursor at `=`. Fill in as desired, then select **Enter** key.

External Keyboard

You can connect an external keyboard to the 4155C/4156C and use to enter text.

Also, you can use the keyboard for other tasks as described in this chapter.

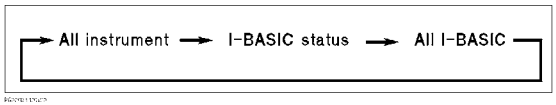
In this section, the notation "**KeyA+KeyB**" means to hold down **KeyA** and press **KeyB**.

Esc — Exits the editor.

F1 through F8 — Primary softkeys. Corresponds to the primary softkeys.

Shift+ F1 through F7 — Secondary softkeys. Corresponds to the secondary softkeys.

F9 — Screen mode. Same as **Ctrl+G**. Toggles the screen mode as follows:



F11 — Clear to end. Deletes characters from cursor to end of line. Same as **Ctrl+Delete**

Shift+F11 — Clear line.

When editor is running, same as **F11**.

When editor is not running, deletes characters on the Command Entry line.

F12 — Clear display. Clears the display for IBASIC. When the editor is running, exits from the editor, and clears the display for IBASIC.

Print Screen — Clear I/O. Stops I/O operation of program.

Scroll Lock — Stop. Stops program execution after executing the current line. Same as **Shift+Pause**.

Shift+Scroll Lock — Reset. Stops program execution immediately.

Pause — Pause. Same as **Ctrl+P**. Pauses program execution until `CONT` is executed or Continue primary softkey is pressed. If the program is modified while paused, `RUN` must be used to restart program execution.

Shift+Pause — Stop. Stops program execution after executing the current line. Same as **Scroll Lock**.

Insert

Insert. Same as **Alt+I**.

When the editor is running, opens a new line before the current line.

When the editor is not running, inserts text at the cursor (press **Insert** again to end insert mode).

Shift+Insert

Insert. Same as **Insert**.

Delete

Delete. Deletes character at the cursor.

Shift+Delete

Delete line. Same as **Alt+D**.

When the editor is running, deletes the current line.

When the editor is not running, deletes character at cursor.

Ctrl+Delete

Clear to end. Deletes characters from cursor to end of line. Same as **F11**.

Home

Beginning of line. Moves the cursor to beginning of the line. Same as **Shift**+ ⇐.

Shift+Home

Page move.

When the editor is running, same as **Page Up**. Also, same as **Shift**+ ⇑.

When the editor is not running, jumps to the top of the IBASIC output area. Also, same as **Shift**+ ⇓.

End

End of line. Moves cursor to end of line. Same as **Shift**+ ⇒.

Shift+End

Page move.

When the editor is running, same as **Page Down**. Also, same as **Shift**+ ⇓.

When the editor is not running, jumps to the bottom of the IBASIC output area. Same as **Shift**+ ⇑.

Page Up

Page move.

When the editor is running, moves the cursor one-half display page toward the beginning of the program. Same as **Shift+Home**. Same as **Shift**+ ⇑.

When the editor is not running, moves display down one page.

Shift+Page Up

Recall.

When the editor is running, displays last deleted line. To enter line into program, press **Enter**.

When the editor is not running, cycles through the 10 commands that were most recently entered on the Command Entry line.

Page Down

Page move.

When the editor is running, moves the cursor one-half display page toward the end of the program. Same as **Shift**+**End**. Same as **Shift**+ ⇓.

When the editor is not running, moves display up one page.

Shift+Page Down

Recall backward.

When the editor is running, same as **Shift**+**Page Up**.

When the editor is not running, cycles through the 10 commands that were most recently entered on the Command Entry line in reverse order of **Shift**+**Page Up**.

⇑

Previous line.

When the editor is running, moves cursor up one line.

When the editor is not running, display on the IBASIC output area moves one line toward the end.

Shift+⇑

Page move.

When the editor is running, same as **Page Up**. Also, same as **Shift**+**Home**.

When the editor is not running, jumps to the bottom of the IBASIC output area. Same as **Shift**+**End**.

Alt+⇑

Recall backward.

When the editor is running, same as **Shift**+**Page Up**.

When the editor is not running, same as **Shift**+**Page Down**.

⇓

Next line.

When the editor is running, cursor moves down one line.

When editor is not running, display on IBASIC output area moves one line toward beginning.

Shift+ ⇓

Page move.

When the editor is running, same as **Page Down**. Also, same as **Shift+End**.

When the editor is not running, jumps to the top of the IBASIC output area. Same as **Shift+Home**.

Alt+ ⇓

Recall. Same as **Shift+Page Up**.

⇐, ⇒

Move cursor. Moves the cursor one character in indicated direction.

Shift+ ⇐

Beginning of line. Moves the cursor to beginning of line. Same as **Home**.

Shift+ ⇒

End of line. Moves the cursor to end of line. Same as **End**.

Backspace

Backspace.

When the editor is running, deletes the character before cursor.

When the editor is not running, deletes the character before cursor (if mode is insert mode). If mode is not insert move, moves cursor to left by one cursor.

Alt+D

Delete line. Same as **Shift+Delete**.

When the editor is running, deletes the current line.

When the editor is not running, deletes the character at the cursor.

Alt+I

Insert line. Same as **Insert**.

When the editor is running, opens a new line before the current line.

When the editor is not running, inserts text at the cursor (press **Insert** again to end insert mode).

Ctrl+U

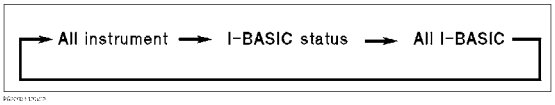
Run. Executes the program.

Ctrl+P

Pause. Same as **Pause**. Pauses program execution until `CONT` is executed or Continue primary softkey is pressed. If the program is modified while paused, `RUN` must be used to restart program execution.

Ctrl+G

Screen mode. Same as **F9**. Toggles the screen mode as follows:



4155C/4156C Specific IBASIC Keywords

The following keywords are not standard IBASIC keywords, or are standard keywords, but with a difference. These keywords are specific to the 4155C/4156C.

EXECUTE Not standard IBASIC keyword. Refer to “ASP-like Commands” in Chapter 5 for details.

ON KEY Standard IBASIC keyword, except the range of *key selector* is 1 to 7. 1 to 7 of *key selector* corresponds to secondary softkeys 1 to 7, respectively.

PEN Standard IBASIC keyword, except the range of *pen selector* is 7. The following table shows the corresponding color for each *pen selector*.

pen selector	**Color**
1	color defined for Foreground on SYSTEM: COLOR SETUP screen.
2	color defined for Y1 Axis on SYSTEM: COLOR SETUP screen.
3	color defined for Y2 Axis on SYSTEM: COLOR SETUP screen.
4	color defined for Marker/Cursor/Line on SYSTEM: COLOR SETUP screen.
5	color defined for Active Mkr/Csr/Lne on SYSTEM: COLOR SETUP screen.
6	color defined for Advisory on SYSTEM: COLOR SETUP screen.
7	color defined for Title on SYSTEM: COLOR SETUP screen.

The following IBASIC keywords are not implemented in the 4155C/4156C's Instrument BASIC.

- ALPHA ON/OFF
- AREA
- CLIP
- CONTROL
- DUMP
- EDGE
- FILL
- FRAME
- GESCAPE
- GLOAD
- GRAPHICS
- GRID
- GSTORE
- LINE TYPE
- PLOTTER IS
- POLYGON
- POLYLINE
- RATIO
- RECTANGLE
- SET PEN
- SHOW
- STATUS
- VIEWPORT
- WINDOW

Available I/O Resources for IBASIC

This section provides information about available I/O resources for IBASIC of the 4155C/4156C.

The following I/O resources are available for IBASIC.

- LCD Display
- External keyboard and front-panel keyboard
- GPIB Interface on rear panel
- Internal pseudo GPIB Interface (to control the 4155C/4156C itself)
- Parallel Interface
- Built-in Flexible Disk Drive (no select code)

The following table shows available I/O interfaces and their select codes.

Select Code	Interface
1	LCD
2	External and front-panel keyboard
7	GPIB Interface on rear panel
8	Internal pseudo GPIB Interface
9	Parallel Interface

LAN interface on the 4155C/4156C rear panel is not available for the built-in IBASIC.

LCD

IBASIC can display text or graphics on the display of the 4155C/4156C.

Following figure shows the display area image on the 4155C/4156C screen.

```
                                (522,479)
(0,479)*-----------------------------*----*(639,479)
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |     Text Display Area       |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                     (522,88)|    |
 (0,88)*-----------------------------*    |
       |      Softkey Display Area        |
       |                                  |
  (0,0)*----------------------------------*(639,0)
                Graphics Display Area
```

Text display

Text can be displayed in the IBASIC output area of "All IBASIC" screen. This area has 23 lines and 58 columns (58 characters in a line), and does not covers the softkey display area.

The x and y coordinate values of the area are as follows:

- lower left corner: (x,y)=(0,88)
- upper right corner: (x,y)=(522,479)

The following table shows the area used to display a character. In this table, *Reserved* column shows the area captured to display a character. This area covers a character, and includes space between characters. *Actual* column shows the area for a character only.

	Reserved	Actual
Size (dots)	9 × 17	5 × 10
Lower Left Corner	(9 × (N-1), 479 -17 × M)	(9 × (N-1), 483 -17 × M)
Upper Right Corner	(9 × N, 479 -17 × (M-1))	(9 × N-4, 476 -17 × (M-1))

where, N and M are integer value (N=1 to 58, M=1 to 23).

Graphics display

In "All IBASIC" screen, you can display a graphical plot.

The x and y coordinate values of this area are as follows:

- lower left corner: (x,y)=(0,0)
- upper right corner: (x,y)=(639,479)

This area covers the softkey display area.

GPIB Interfaces

- Internal pseudo GPIB

  By using select code 8, you can control the 4155C/4156C via internal pseudo GPIB interface. The GPIB address of the 4155C/4156C has no meaning, so you can use any address (0 through 30).

- GPIB on rear panel

  You can access GPIB interface on rear panel by using select code 7.

Parallel Interface

You can use parallel interface on the rear panel for the printer interface. Select code is 9.

Built-in Flexible Disk Drive

If you specify optional volume specifier when accessing the built-in flexible disk drive, the volume specifier must be ":INTERNAL,4".

Available diskettes

You can use the following types of 3.5 inch diskettes:

- 2HD 1.44 MB
- 2DD 720 KB

Diskette must be formatted as LIF or the following DOS format:

- 80 tracks/side
- 18 sectors/track (2HD), 9 sectors/track (2DD)
- 512 bytes/sector

Differences from 4155A/4156A Programming

Programming differences between the 4155A/4156A and the 4155C/4156C come from the differences of the screen and the SCPI commands supported by the instruments.

For the most case, you can execute the IBASIC program created for the 4155A/4156A on the 4155C/4156C built-in IBASIC controller. But the following programs should be modified to execute on the 4155C/4156C's IBASIC controller.

- Programs use both text display and graphics display.
- Programs use the :HCOPy:DESTination command.
- Programs use the :HCOPy:DEVice:LANGuage command.

This section provides the information to modify the program.

For the SCPI commands which the 4155A/4156A does not support but the 4155C/4156C supports, refer to “Differences From 4155B/4156B SCPI Commands” and “Differences From 4155A/4156A SCPI Commands” in Chapter 2.

NOTE

Executing the IBASIC program created for the 4155B/4156B

The IBASIC programs for the 4155B/4156B can be executed on the 4155C/4156C. You do not need to modify the programs.

NOTE

Using 4155C/4156C FLEX Command Set

If you use the 4155C/4156C FLEX command set, you cannot reuse the *SCPI* programs of the 4155A/4156A, and you need to create new program.

Refer to Chapter 3.

Using Text Display and Graphics Display

By the difference of the screen, the 4155C/4156C display area is different from the 4155A/4156A as shown in the following table. So if you execute the IBASIC program for the 4155A/4156A on the 4155C/4156C built-in IBASIC controller, the graphics will lie on the text.

Modify the program by using the following information.

	4155A/4156A	**4155C/4156C**
Text display [a]	58 characters/line	58 characters/line
	23 lines	23 lines
	814 dots/character	917 dots/character
Graphics display [b]	lower left (0,0)	lower left (0,0)
	upper right (546,399)	upper right (639,479)

a. Text display area does not cover the softkey display area.
b. Graphics display area covers the text display area and the softkey display area.

Following figure shows the display area image on the 4155C/4156C screen.

```
                                (522,479)
(0,479)*-----------------------------*----*(639,479)
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |     Text Display Area       |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                             |    |
       |                     (522,88)|    |
 (0,88)*-----------------------------*    |
       |      Softkey Display Area        |
       |                                  |
  (0,0)*----------------------------------*(639,0)
                Graphics Display Area
```

The following table shows the area used to display a character. In this table, *Reserved* column shows the area captured to display a character. This area covers a character, and includes space between characters. *Actual* column shows the area for a character only.

where, N and M are integer value (N=1 to 58, M=1 to 23).

	Reserved	**Actual**
Size (dots)	9 × 17	5 × 10
Lower Left Corner	(9 × (N-1), 479 -17 × M)	(9 × (N-1), 483 -17 × M)
Upper Right Corner	(9 × N, 479 -17 × (M-1))	(9 × N-4, 476 -17 × (M-1))

Using :HCOP:DEST Command

From differences of the supported interfaces, the command parameters are different from the 4155A/4156A as shown below:

Model	**Serial**	**Parallel**	**GPIB**	**LAN**	**file**
4155A/4156A	SERial		RDEVice		MMEMory
4155C/4156C		PARallel	RDEVice	NET*n*	MMEMory

where, *n* is 1, 2, 3 or 4.

The meaning of the parameters is as follows:

SERial Selects serial interface.

PARallel Selects parallel interface.

RDEVice Selects GPIB interface.

NET*n* Selects a remote printer. *n*= 1, 2, 3 or 4.

MMEMory Not make hardcopy. Outputs to a file in the device specified by the :MMEM:DEST command.

Using :HCOP:DEV:LANG Command

Differences of the supported output format for the print/plot function make the differences on the command parameters as shown below.

Model	PCL	HR PCL [a]	HP-GL	TIFF	HR TIFF [b]
4155A/4156A	PCL		HPGL		
4155C/4156C	PCL	HRPCl	HPGL	TIFF	HRTIff

a. high resolution PCL.
b. high resolution TIFF.

The meaning of the parameters is as follows:

PCL Selects PCL format.

HRPCl Selects high resolution PCL format.

HPGL Selects HP-GL format.

TIFF Selects TIFF format. For file output only.

HRTIff Selects high resolution TIFF format. For file output only.

2 SCPI Command Programming

Standard Commands for Programmable Instruments (SCPI) is a universal programming language for electronic test and measurement instruments, and based on IEEE 488.1 and IEEE488.2.

This chapter describes how to create programs that contain SCPI commands to control Agilent 4155C/56C, and consists of the following sections.

- SCPI Programming Basics
- Getting Started on SCPI Programming
- Measurement Setup
- Auto Analysis Setup
- Measurement Execution
- File Operation
- Data Transfer
- Print/Plot Operation
- Other Programming Tips
- Example for 4145 Users

If you are not familiar with the 4155C/4156C programming, “Getting Started on SCPI Programming” on page 2-8 provides step-by-step tutorials for programming and helps you to understand quickly.

In addition to this chapter, *Sample Application Programs Guide Book* provides some application examples which are helpful to increase your understanding.

Refer to *SCPI Command Reference* for the command syntax and description of the SCPI commands available for the 4155C/4156C.

SCPI Programming Basics

This section provides the following basic tasks to control and program the 4155C/4156C:

- “Preparation before Controlling 4155C/56C via GPIB”
- “SCPI Command Hierarchy”
- “To Control 4155C/56C by HP BASIC Programming”

Preparation before Controlling 4155C/56C via GPIB

You can use an external computer or the built-in Instrument BASIC (IBASIC) controller to control the 4155C/4156C via GPIB.

NOTE

Device Clear

The 4155C/4156C requires approx. 0.5 seconds for the GPIB device clear. For the HP BASIC or IBASIC, enter CLEAR command.

Controlling from external computer

You must do as follows before controlling the 4155C/4156C from an external computer:

1. Connect the GPIB interface of external computer to GPIB interface on rear panel of the 4155C/4156C.
2. Set the `4155C/56C is` field on the SYSTEM: MISCELLANEOUS screen to NOT SYSTEM CONTROLLER.
3. Enter the GPIB address of your 4155C/4156C into the `GPIB ADDRESS` field.

Controlling from built-in IBASIC controller

If you use built-in IBASIC controller to control only the 4155C/4156C, you do not need to prepare anything before controlling the 4155C/4156C because built-in IBASIC controller is always connected to the 4155C/4156C via internal GPIB.

However, to control external instruments, do following:

1. Connect the GPIB interface of external instruments to GPIB interface on rear panel of the 4155C/4156C.
2. Set "`4155C/56C is`" field on the SYSTEM: MISCELLANEOUS screen to SYSTEM CONTROLLER.

To use the 4155C/4156C print/plot function, do following:

1. Connect printer/plotter to the 4155C/4156C.
2. If the printer/plotter interface is GPIB:
   a. Set "`4155C/56C is`" field to SYSTEM CONTROLLER before executing printing/plotting out.
   b. Enter the GPIB address of printer/plotter into "`GPIB ADDRESS`" "`HARD COPY`" field on the SYSTEM: MISCELLANEOUS screen.
3. If you use the remote printer connected to the print server:
   a. Connect the 4155C/4156C to your LAN.
   b. Set the "`4155C/56C NETWORK SETUP`" table and "`NETWORK PRINTER SETUP`" table on the SYSTEM: MISCELLANEOUS screen.

To use the network file system on the NFS server, do following:

1. Connect the 4155C/4156C to your LAN.
2. Set the "`4155C/56C NETWORK SETUP`" table and "`NETWORK DRIVE SETUP`" table on the SYSTEM: MISCELLANEOUS screen.

SCPI Command Hierarchy

SCPI commands use a hierarchical structure for subsystem commands similar to the file system.

For example, in `:PAGE:MEASURE:SWEEP` command, the hierarchy is as follows:

`PAGE`	root
`MEASURE`	sub-level 1
`SWEEP`	sub-level 2

The colon at the beginning of the command means root. The colons between two command keywords means moving down to a lower level.

NOTE

Using a Semicolon to Reduce Typing

A semicolon enables two commands to be sent on the same line.

For example, `:PAGE:MEAS:VAR1:START 0;STOP 5` is the same as the following two commands:

```
:PAGE:MEAS:VAR1:START 0
:PAGE:MEAS:VAR1:STOP 5
```

So, using a semicolon reduces typing and simplifies the program.

A command terminator (such as a `<newline>`) resets the path to root.

To Control 4155C/56C by HP BASIC Programming

1. Assign I/O path for controlling the 4155C/4156C.

   Use ASSIGN command to assign I/O path:

   - Built-in IBASIC

     Specify select code 8. For the GPIB address, you can use *any* number between 0 to 31. Refer to the following example:

     ```
     10 ASSIGN @Hp415x TO 800
     ```

   - HP BASIC on an external computer

     Specify the select code of the external computer. And specify the GPIB address that you entered into the GPIB ADDRESS field on the SYSTEM: MISCELLANEOUS screen. In the following example, the select code of the external computer is 7 and GPIB address of the 4155C/56C is 17:

     ```
     10 ASSIGN @Hp415x TO 717
     ```

2. Use OUTPUT command to send commands to the 4155C/4156C.
3. Use ENTER command to get query response from the 4155C/4156C.

Example

The following is the example program to control the 4155C/4156C:

```
10   DIM I3(1:501)
20   !
30   ASSIGN @Hp415x TO 717
40   !
50   OUTPUT @Hp415x;"*RST"
60   !
70   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES','DISK'"
80   !
90   OUTPUT @Hp415x;":PAGE:SCON:SING"
100  OUTPUT @Hp415x;"*OPC?"
110  ENTER @Hp415x;Complete
120  !
130  OUTPUT @Hp415x;":FORM:DATA ASC"
140  OUTPUT @Hp415x;":DATA? 'I3'"
150  ENTER @Hp415x;I3(*)
160  !
170  END
```

Line Number	Description
30	Assigns I/O path to control the 4155C/4156C.
50	Resets the 4155C/4156C by sending *RST command.
70	Loads measurement setup data from diskette file `SWP.MES`.
90 to 110	Executes measurement
130 to 150	Gets the measurement data

Getting Started on SCPI Programming

This section provides step-by-step tutorials for programming to control the 4155C/4156C along with programming examples. In this section, you do SCPI programming by using the built-in IBASIC.

This section consists of the following sections:

- “Creating a Simple Measurement Program”

  This section introduces how to create a measurement program.

- “Programming for Data Extraction”

  This section provides the programming tutorials for data extraction.

- “Complete Example Program for Vth Measurement”

  This section shows complete example program based on the parts described in the other sections.

- “Example Application Setup for Vth Measurement”

  This section describes an example application setup that you should save to the file named `VTH.MES` on diskette before executing program examples (that use `VTH.MES`) described in this section.

Creating a Simple Measurement Program

This section introduces how to create a measurement program.

A simple measurement program created by using built-in IBASIC controller is provided as an example and you learn step-by-step how to create a measurement program.

This section consists of the following:

1. Getting a setup file from a diskette and making a measurement
2. Changing the sweep setup parameters
3. Changing the display setup parameters
4. Saving the measurement results to a diskette
5. Printing the measurement results

Before Creating a Program

This section assumes that you have already saved a measurement setup file for Vth measurement to diskette.

Prepare the diskette and save the measurement setup (described in “Example Application Setup for Vth Measurement” on page 2-26) to the file named "VTH.MES" on the diskette.

Before starting this section, do following:

1. If the 4155C/4156C has already been turned on, turn the 4155C/4156C off.
2. Connect a printer to the parallel interface or GPIB interface on the rear panel. You will use the printer at Step 5.
3. Turn the 4155C/4156C on.
4. Set the SYSTEM: PRINT/PLOT SETUP screen and SCREEN DUMP dialog as you want. Or set only the "`DESTINATION`" and "PAPER" fields on the SYTEM: PRINT/PLOT SETUP screen.
5. If you use the GPIB printer:
   a. Set "`4155C/56C is`" field on the SYSTEM: MISCELLANEOUS screen to SYSTEM CONTROLLER.
   b. Enter the GPIB address of printer/plotter into "`GPIB ADDRESS`" "`HARD COPY`" field.

Step 1 **Getting the Setup File and Making a Measurement**

In this step, you can create a program to get a setup file from the diskette and execute a measurement.

1. Press IBASIC **Display** key until screen display mode is All IBASIC mode.
2. Select EDIT softkey, then press **Enter** key to start the IBASIC editor.
3. If there is an existing program, save it if necessary.
4. Delete existing program and assign I/O path to control the 4155C/56C.

   Type `SCRATCH`, then **Enter**. Or select Scratch primary softkey, then YES secondary softkey to delete the program.

   Existing program is deleted and the following program lines are entered automatically. These lines are for assigning the 4155C/56C control I/O path.

```
  10 COM @Hp415x
  20 ASSIGN @Hp415x TO 800
  30 !
9990 END
```

   line 10 — Declares COM so that subprograms can access the I/O path (that is assigned in line 20) for controlling the 4155C/56C. Refer to the *Instrument BASIC Users Handbook* for details.

   line 20 — Assigns the I/O path for controlling the 4155C/56C. `800` means built-in IBASIC controller.

5. Select OUTPUT @Hp415x secondary softkey.

   The following characters are automatically entered:

```
30 OUTPUT @Hp415x;""
```

   Do not press **Enter** yet.

6. Use the help function to find the command for getting a setup file:

   a. Press **Help**.

   b. Press **Get**.

   The cursor in help window automatically jumps to the command (:MMEM:LOAD:STAT) for getting a setup file.

7. Press **Enter** to insert the command into the program line.

   Now line 30 is as follows:

```
30 OUTPUT @Hp415x;":MMEM:LOAD:STAT"
```

8. Type in the command parameters as in following example:

```
30 OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.MES','DISK'"
```

The following table shows the meaning of the parameters:

Parameter	Description
0	Dummy parameter (no meaning).
VTH.MES	File name to be loaded.
DISK	Source mass storage is diskette.

Then press **Enter**. Then select the Insert line softkey.

To Specify Mass Storage Device

When the 4155C/4156C is in the power on state, the mass storage device is set to the built-in flexible disk drive.

If you specify the device, enter the :MMEM:DEST command before the :MMEM:LOAD:STAT command. The following parameters are available for the :MMEM:DEST command:

INTernal Selects the built-in flexible disk drive.

NET*n* Selects the NFS server. *n*= 1, 2, 3 or 4.

9. Select OUTPUT @Hp415x secondary softkey.

```
40 OUTPUT @Hp415x;""
```

10. Press **Help**, then press **Single**, **Append**, or **Repeat** to find the command for executing a measurement.

Relation between the execution keys and commands are shown below:

Execution Key	Command
Single	:PAGE:SCON:MEAS:SING
Append	:PAGE:SCON:MEAS:APP
Repeat	:PAGE:SCON:MEAS:REP

11. Press **Enter** to insert the found command into the program line.

```
   10 COM @Hp415x
   20 ASSIGN @Hp415x TO 800
   30 OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.MES','DISK'"
   40 OUTPUT @Hp415x;":PAGE:SCON:MEAS:SING"
 9990 END
```

    Then press **Enter**

12. Press End edit softkey to exit from the editor.

Now you have created a measurement program.

To execute the program, do as follows:

1. Press IBASIC **Display** key until screen display mode is All Instrument or IBASIC Status mode. This allows you to monitor the measurement on GRAPH/LIST: GRAPHICS screen.
2. Press **Run** front-panel key. The measurement program is executed.

Step 2 **Changing the Sweep Setup Parameters**

Modify measurement program created in previous step so that you can enter new sweep start and stop values while program is running:

1. Press IBASIC **Display** key until the screen display mode is All IBASIC mode.
2. Select EDIT softkey, then press **Enter** key to start the IBASIC editor.
3. Insert program lines that allow you to enter the sweep start and stop values from the keyboard during program running.
   a. Move the cursor to program line 30.
   b. Select Insert line primary softkey.
   c. Type the following program lines:

```
21 !
22 INPUT "Sweep Start (V)?",Start_v
23 INPUT "Sweep Stop (V)?",Stop_v
24 !
```

4. If you do not know the SCPI commands for changing the sweep start and stop parameters, do as follows:
   a. Press IBASIC **Display** key until screen display mode is All Instrument mode.
   b. Press **Meas** to change to MEASURE: SWEEP SETUP screen.
   c. Move the field pointer to the parameter that you want to change.
   d. Press **Help** key.

      The corresponding command is displayed at the bottom of the help window: You need to remember the commands, so that you can enter them in the next step.

Command	Description
:PAGE:MEAS:SWE:VAR1:STAR	VAR1 sweep start
:PAGE:MEAS:SWE:VAR1:STOP	VAR1 sweep stop

   e. Select the EXIT HELP softkey.

5. Press IBASIC **Display** key until screen display mode is All IBASIC mode. Then, do the following to insert the program lines for changing the sweep start and stop values.

   a. Move the cursor to the program line 40.

   b. Select Insert line primary softkey.

   c. Select the OUTPUT @Hp415x softkey.

   d. Type in the SCPI command. Or you can use the help function to enter the command. For the help function, see “To Use the Help Function” in Chapter 1.

      After you finish, the program lines should look as follows:

```
31 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR ";Start_v
32 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP ";Stop_v
```

   Now the program is as follows:

```
  10 COM @Hp415x
  20 ASSIGN @Hp415x TO 800
  21 !
  22 INPUT "Sweep Start (V)?",Start_v
  23 INPUT "Sweep Stop (V)?",Stop_v
  24 !
  30 OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.MES','DISK'"
  31 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR ";Start_v
  32 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP ";Stop_v
  40 OUTPUT @Hp415x;":PAGE:SCON:MEAS:SING"
9990 END
```

6. Select End edit softkey to exit from the editor.

7. Press IBASIC **Display** key until screen display mode is IBASIC Status mode.

8. Press **Run** to execute the program.

9. `Sweep Start (V)?` is displayed on the display line. Enter the desired sweep start voltage.

10. `Sweep Stop (V)?` is displayed on the display line. Enter the desired sweep stop voltage.

Step 3 **Changing the Display Setup Parameters**

In this step, change X-axis range of display setup parameters to match the sweep start and stop values.

1. Press IBASIC **Display** key until screen display mode is All IBASIC mode.
2. Select EDIT softkey, then press **Enter** key to start the IBASIC editor.
3. If you do not know the SCPI commands for changing the X-axis parameters, do as follows:
   a. Press IBASIC **Display** key until screen display mode is All Instrument mode.
   b. Press PAGE CONTROL **Display** key to change to DISPLAY: DISPLAY SETUP screen.
   c. Move the field pointer to the parameter that you want to change.
   d. Press **Help** key.

      The corresponding commands are displayed at the bottom of the help window. You need to remember the commands, so that you can enter them in the next step.

Command	Description
:PAGE:DISP:SET:GRAP:X:MIN	minimum value of X-axis
:PAGE:DISP:SET:GRAP:X:MAX	maximum value of X-axis

   e. Select the EXIT HELP softkey.
4. Press IBASIC **Display** key until screen display mode is All IBASIC mode. Then, do the following to insert the program lines for changing the X-axis display parameters:
   a. Move the cursor to the program line 40.
   b. Select Insert line primary softkey.
   c. Select the OUTPUT @Hp415x softkey.
   d. Type in the SCPI command. Or you can use the help function to enter the command. For the help function, see “To Use the Help Function” in Chapter 1. After you finish, the program lines should look as follows:

```
33 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MIN ";Start_v
34 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MAX ";Stop_v
```

Now the program is as follows:

```
  10 COM @Hp415x
  20 ASSIGN @Hp415x TO 800
  21 !
  22 INPUT "Sweep Start (V)?",Start_v
  23 INPUT "Sweep Stop (V)?",Stop_v
  24 !
  30 OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.MES','DISK'"
  31 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR ";Start_v
  32 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP ";Stop_v
  33 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MIN ";Start_v
  34 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MAX ";Stop_v
  40 OUTPUT @Hp415x;":PAGE:SCON:MEAS:SING"
9990 END
```

5. Select End edit softkey to exit from the editor.
6. Press IBASIC **Display** key until screen mode is IBASIC Status mode.
7. Press **Run** to execute the program.
8. Enter the desired sweep start and stop values as prompted. The minimum and maximum X-axis values of the graph will be the same as these entered values.

Step 4 Saving All Measurement Results to a Diskette

In this step, add program lines that save the setup data and measurement results to the diskette.

1. Press IBASIC **Display** key until screen display mode is All IBASIC mode.
2. Select EDIT softkey, then press **Enter** key to start the IBASIC editor.
3. Move the cursor to program line 9990.
4. Select Insert line primary softkey.
5. Insert the following program lines, which wait until the measurement is completed.

   ```
   50 OUTPUT @Hp415x;"*OPC?"
   60 ENTER @Hp415x;Complete
   ```

   When measurement is completed, the 4155C/56C returns `1` to the `Complete` variable.

6. Insert the following program line, which saves the measurement setup and results to a file named `VTH.DAT`:

   ```
   70 OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'VTH.DAT'"
   ```

   Now the program is as follows:

   ```
     10 COM @Hp415x
     20 ASSIGN @Hp415x TO 800
     21 !
     22 INPUT "Sweep Start (V)?",Start_v
     23 INPUT "Sweep Stop (V)?",Stop_v
     24 !
     30 OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.MES','DISK'"
     31 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR ";Start_v
     32 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP ";Stop_v
     33 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MIN ";Start_v
     34 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MAX ";Stop_v
     40 OUTPUT @Hp415x;":PAGE:SCON:MEAS:SING"
     50 OUTPUT @Hp415x;"*OPC?"
     60 ENTER @Hp415x;Complete
     70 OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'VTH.DAT'"
   9990 END
   ```

7. Select End edit softkey to exit from the editor.
8. Press IBASIC **Display** key until screen display mode changes to IBASIC Status mode.
9. Press **Run** to execute the program.

   The measurement setup and results are automatically saved to the diskette after measurement is performed.

Step 5 Printing the Measurement Results

In this step, add program lines that print the measurement results.

1. Press **Display** key until screen display mode is All IBASIC mode.
2. Select EDIT softkey, then press **Enter** key to start the IBASIC editor.
3. Move the cursor to the program line 70.
4. Select Insert line primary softkey.
5. Insert the following program lines, which print a screen dump of the results:

```
61 OUTPUT @Hp415x;":HCOP:SDUM"
62 DISP "Printing"
63 OUTPUT @Hp415x;"*OPC?"
64 ENTER @Hp415x;Complete
65 DISP "Done"
```

`:HCOP` immediately initiates the plot or print according to the current setup. After printing is finished, the 4155C/56C returns `1` to the `Complete` variable, then "Done" is displayed on the screen.

Now the program is as follows:

```
  10 COM @Hp415x
  20 ASSIGN @Hp415x TO 800
  21 !
  22 INPUT "Sweep Start (V)?",Start_v
  23 INPUT "Sweep Stop (V)?",Stop_v
  24 !
  30 OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.MES','DISK'"
  31 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR ";Start_v
  32 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP ";Stop_v
  33 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MIN ";Start_v
  34 OUTPUT @Hp415x;":PAGE:DISP:SET:GRAP:X:MAX ";Stop_v
  40 OUTPUT @Hp415x;":PAGE:SCON:MEAS:SING"
  50 OUTPUT @Hp415x;"*OPC?"
  60 ENTER @Hp415x;Complete
  61 OUTPUT @Hp415x;":HCOP:SDUM"
  62 DISP "Printing"
  63 OUTPUT @Hp415x;"*OPC?"
  64 ENTER @Hp415x;Complete
  65 DISP "Done"
  70 OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'VTH.DAT'"
9990 END
```

Programming for Data Extraction

This section provides the following programming tutorials for data extraction:

1. Reading the 4155/56 setup data
2. Reading values of data variables (measurement results)
3. Transferring data into a file

Step 1

Reading 4155/56 Setup Data

To read setup data from the 4155/56 into an IBASIC variable, use the query form of the corresponding setting command. To make the query form of a command, simply add a question mark (?) to the end of the command.

Refer to the following program lines of example program:

```
 60 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR?"
 70 ENTER @Hp415x;Vd_start
 80 OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP?"
 90 ENTER @Hp415x;Vd_stop
100 OUTPUT @Hp415x;":DISP:ALL BAS"
110 CLEAR SCREEN
120 PRINT TABXY(1,1);"Vd START=";Vd_start;"(V)"
130 PRINT TABXY(1,2);"Vd STOP =";Vd_stop;"(V)"
```

Line 60	This query command tells the 4155C/56C to put the VAR1 start value in its output buffer. `:PAGE:MEAS:SWE:VAR1:STAR` is the command for setting the VAR1 start value. By adding `?`, the command becomes the query command for reading the VAR1 start value.
Line 70	This gets the start value from the output buffer, then enters it in the `Vd_start` variable.
Line 80 to 90	These lines tell the 4155C/56 to put VAR1 stop value in its output buffer, then the value is entered into the `Vd_stop` variable.

Step 2

Reading 4155/56 Measurement Data

To read read-out function values or data variable values (output data, measurement data, and user function values) from the 4155/56 to IBASIC variables, use the `:DATA?` command.

Refer to the following program lines in the example program:

```
410 OUTPUT @Hp415x;":PAGE:SCON:MEAS:SING"
420 OUTPUT @Hp415x;"*OPC?"
430 ENTER @Hp415x;Complete
440 OUTPUT @Hp415x;":DATA? 'VTH'"
450 ENTER @Hp415x;Vth
```

Line 410	Execute single measurement.
Line 420 to 430	Wait for measurement completion.
Line 440	Send `:DATA?` query command to read the result value of user function "VTH".
Line 450	Store the result value into `Vth` variable.

NOTE

Variable Names

Be aware that data variable names, such as user functions and user variables, are *case sensitive*. For example, if you set up user function name `VTH` on the CHANNEL: USER FUNCTION DEFINITION screen, then to read it, you must use :DATA? 'VTH', not :DATA? 'Vth'.

Step 3 **Transferring Specific 4155/56 Data to a File**

To transfer data from the 4155C/56C to a file, do as follows:

1. Create a data file.
2. Open an I/O path for transferring data into the file.
3. Store data into the file.
4. Close the I/O path.

Create a data file

You can create three types of data files: DOS, LIF ASCII, or BDAT as follows:

```
CREATE "data_file",1            ! Creates a DOS file.
CREATE ASCII "ascii_file",100   ! Creates a LIF ASCII file.
CREATE BDAT "binary_file",100   ! Creates a BDAT file.
```

DOS files are compatible with MS-DOS, which are easy to transfer to PCs and other computers.

LIF ASCII files are compatible with HP computers that support this file type, so this type is best is you are transferring files among HP computers that support this file type.

BDAT (binary data) files provide more flexibility (can specify both number of records and record length) and faster transfer rate. But BDAT files cannot be interchanged with as many other systems.

The first parameter of each statement specifies the file name to create.

The second parameter specifies number of records to allocate for the file as follows:

DOS Second parameter specifies how many records are to be *initially* allocated for the file. A DOS file system automatically allocates additional space for the file as new data is written to it, so you can always specify `1` for this parameter.

LIF ASCII Second parameter specifies *total* number of records to allocate for the file, so you must specify a sufficient number of records. The length of one record is 256 bytes.

For example, the following statement would create a file with 100 records (each record is 256 bytes):

```
CREATE ASCII "File",100
```

BDAT Second parameter specifies *total* number of records to allocate for the file, so you must specify a sufficient number of records. You can specify a record length by using an optional third parameter (default length is 256 bytes).

For example, the following statement creates a file with 7 records (each record is 128 bytes):

```
CREATE BDAT "B_file",7,128
```

The following statement creates a file with 7 records (each record is 256 bytes):

```
CREATE BDAT "B_file",7
```

Open an I/O path for transferring data into the file

To open an I/O path to the file, assign an I/O path name to the file by using an ASSIGN statement as in the following example:

```
340 INPUT "Enter file name to store data",File$
350 CREATE File$,1
360 ASSIGN @File TO File$;FORMAT ON
```

Line 350 creates a DOS file, then line 360 opens an I/O path to the file.

For DOS and BDAT files, ASSIGN statement can also specify the following:

FORMAT ON ASCII data representations are used. Specify this if you need to transport data between IBASIC and other machines.

FORMAT OFF IBASIC internal data representations are used. Specify this if you need a faster transfer rate and space efficiency.

Store data into the file

To store data into a file, use `OUTPUT` and `ENTER` statements as in the following examples:

```
340 INPUT "Enter file name to store data",File$
350 CREATE File$,1
360 ASSIGN @File TO File$;FORMAT ON
       :
390 REPEAT
       :
440   OUTPUT @Hp415x;":DATA? 'VTH'"
450   ENTER @Hp415x;Vth
460   OUTPUT @File;Vth
       :
630 UNTIL Stop$="S" OR Stop$="s"
```

The above program repeats appending `Vth` variable value to a DOS file in ASCII format.

In addition to numeric data, array data and string data can be stored to a file as in following examples:

- Array data:

```
1    DIM Vth(1:100)
    :
340    INPUT "Enter file name to store data",File$
350    CREATE File$,1
360    ASSIGN @File TO File$;FORMAT ON
    :
390  FOR I=1 TO 100
    :
440      OUTPUT @Hp415x;":DATA? 'VTH'"
450      ENTER @Hp415x;Vth(I)
460  NEXT I
470  OUTPUT @File;Vth(*)
    :
```

- String data:

```
10  DIM Data$[10](1:100)
20  CREATE "DATAFILE",1
30  ASSIGN @File TO "DATAFILE";FORMAT ON
40  FOR I=1 TO 100
50   Data$(I)="ABC"
60  NEXT I
70  OUTPUT @File;Data$(*)
   :
```

Close the I/O path

To close an I/O path to a file, `ASSIGN` the path name to an (asterisk) as in the following example:

```
340   INPUT "Enter file name to store data",File$
350   CREATE File$,1
360   ASSIGN @File TO File$;FORMAT ON
     :
460   OUTPUT @File;Vth
     :
590   ASSIGN @File TO *
```

In this program, line 590 closes the I/O path that was opened by line 360.

Complete Example Program for Vth Measurement

The example program shown below uses the measurement setup file described in "Example Application Setup for Vth Measurement" on page 2-26. This is a complete example program based on the parts described in the previous sections.

```
10      COM @Hp415x
20      ASSIGN @Hp415x TO 800
30      OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.MES','DISK'"
40     !
50     ! Read and Disp. Measurement Conditions
60      OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR?"
70      ENTER @Hp415x;Vd_start
80      OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP?"
90      ENTER @Hp415x;Vd_stop
100     OUTPUT @Hp415x;":DISP:ALL BAS"
110     CLEAR SCREEN
120     PRINT TABXY(1,1);"Vd START=";Vd_start;"(V)"
130     PRINT TABXY(1,2);"Vd STOP =";Vd_stop;"(V)"
140    !
150    ! Parameter Change
160     Change$="n"
170 Change:   !
180     INPUT "Change these parameters? (y/n default=n)",Change$
190     SELECT Change$
200     CASE "Y","y"
210       INPUT "New Vd START (V)?",Vd_start
220       INPUT "New Vd STOP (V)?",Vd_stop
230       OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STAR ";Vd_start
240       OUTPUT @Hp415x;":PAGE:MEAS:SWE:VAR1:STOP ";Vd_stop
250       PRINT TABXY(1,1);"Vd START=";Vd_start;"(V)"
260       PRINT TABXY(1,2);"Vd STOP =";Vd_stop;"(V)"
270     CASE "N","n"
280       GOTO Store_file
290     CASE ELSE
300       GOTO Change
310     END SELECT
320    !
330 Store_file:   !
340     INPUT "Enter file name to store data",File$
350     CREATE File$,1
360     ASSIGN @File TO File$;FORMAT ON
370    !
380     No_of_data=0
390     REPEAT
400       OUTPUT @Hp415x;":DISP:ALL BST"
410       OUTPUT @Hp415x;":PAGE:SCON:MEAS:SING"
420       OUTPUT @Hp415x;"*OPC?"
430       ENTER @Hp415x;Complete
440       OUTPUT @Hp415x;":DATA? 'VTH'"
450       ENTER @Hp415x;Vth
460       OUTPUT @File;Vth
470       No_of_data=No_of_data+1
480       OUTPUT @Hp415x;":DISP:ALL BASIC"
490       PRINT TABXY(1,10);"Last measured Vth =";Vth;"(V)"
500       PRINT TABXY(1,11);"Total number of die tested=";No_of_
data
```

```
510 Stop_query:INPUT "Continue to next die or Stop test? (c/s)"
,Stop$
520      SELECT Stop$
530      CASE "C","c"
540        DISP "Move to the next die, then press [Continue]"
550        PAUSE
560        DISP ""
570      CASE "S","s"
580        PRINT TABXY(1,24);"Test Stopped!!"
590        ASSIGN @File TO *
600      CASE ELSE
610        GOTO Stop_query
620      END SELECT
630    UNTIL Stop$="S" OR Stop$="s"
640    END
```

Example Application Setup for Vth Measurement

This section describes an example application setup that you should save to the file named `VTH.MES` on diskette before executing program examples (that use `VTH.MES`) described previously in this section.

A frequently used method of measuring Vth is to synchronously sweep the exact same voltage to gate and drain, and measure the characteristics in the saturation region.

The theoretical value of drain current in the saturation region is calculated as follows:

$$Id = \beta \times (Vg - Vth)^2$$

Where β is the gain factor, which is $-1/2 \times (\mu\varepsilon_{ox} W/L) \times t_{ox}$. Therefore, if you take the square root of both sides of the equation:

$$\sqrt{Id} = \sqrt{\beta} \times (Vg - Vth)$$

$\sqrt{Id}$ is proportional to Vg, and the slope is $\sqrt{\beta}$. At the point where $\sqrt{Id}$ is equal 0, *Vth* is equal to *Vg*. So, to know *Vth*, we need to find that point.

The measurement conditions are explained below:

CHANNELS: CHANNEL DEFINITION

- MEASUREMENT MODE

SWEEP

- CHANNELS

MEASURE				
UNIT	**VNAME**	**INAME**	**MODE**	**FCTN**
SMU1	Vd	Id	V	VAR1'
SMU2	Vg	Ig	V	VAR1
SMU3	Vs	Is	COMMON	CONST
SMU4	Vsb	Isb	V	CONST

MEASURE: SWEEP SETUP

This is the sweep source setup for the Id-Vg characteristics measurement.

- VARIABLE

	VAR1		VAR1’
UNIT	**SMU2**	**UNIT**	**SMU1**
NAME	**Vg**	**NAME**	**Vd**
SWEEP MODE	SINGLE	**OFFSET**	0.0000 V
LIN/LOG	LINEAR	**RATIO**	1.000
START	0.0000 V	**COMPLIANCE**	100.00 mA
STOP	5.000 V	**POWER COMP**	OFF
STEP	100.0 mV		
NO OF STEP	51		
COMPLIANCE	100.0 mA		
POWER COMP	OFF		

- CONSTANT

UNIT	**SMU4**
NAME	**Vsb**
MODE	**V**
SOURCE	0.0000 V
COMPLIANCE	100.00 mA

CHANNELS: USER FUNCTION DEFINITION

The following setup is necessary to calculate SQRTId (square root of Id), and GRAD (differential coefficient of SQRTId) versus Vg automatically. VTH and BETA are defined to extract Vth and β automatically by using the Read Out Functions and the Auto Analysis Functions. VTH is @L1X (X-intercept of line 1) and BETA is @L1G^2 (slope of line 1 to second power). Line 1 is drawn according to the definitions of the DISPLAY: ANALYSIS SETUP screen.

- USER FUNCTION

NAME	UNIT	DEFINITION
SQRTId		SQRT(Id)
GRAD		DIFF(SQRTId,Vg)
VTH	V	@L1X
BETA		@L1G^2

DISPLAY: DISPLAY SETUP

The following setup is to plot two curves: SQRTId versus Vg, and GRAD versus Vg. And VTH and BETA will be displayed in the data variables display area.

- GRAPHICS

	X-axis	**Y1-axis**	**Y2-axis**
NAME	Vg	SQRTId	GRAD
SCALE	LINEAR	LINEAR	LINEAR
MIN	0 V	0	0
MAX	5 V	200 m	80 m

- GRID

ON

- LINE PARAMETER

ON

- DATA VARIABLES

VTH
BETA

DISPLAY: ANALYSIS SETUP

The Auto Analysis Functions are defined on DISPLAY: ANALYSIS SETUP screen.

A tangent line (line 1) is drawn to "SQRTId versus Vg" curve (Y1) at point where GRAD is maximum. VTH is the X-intercept of this line. Also, the marker is moved to point where GRAD is maximum.

*** LINE1**	TANGENT	**line on**	Y1	**at a point where**
GRAD	=	MAX(GRAD)		

If you execute a single measurement, the two curves are drawn. Right after the measurement, a tangent line is drawn as specified in DISPLAY: ANALYSIS SETUP screen, and resulting VTH and BETA values are displayed.

Programming: Measurement Setup

To set up a measurement, you can use SCPI commands to set the setup screens of the 4155C/4156C the same way that you can by interactive operation.

Basically, there are the following three ways to set up a measurement via SCPI programming:

- Load the measurement setup data from diskette, NFS server or internal memory.

  Load the measurement setup data by SCPI programming. The data was previously defined and stored to the mass storage memory interactively or by SCPI programming.

- Load the measurement setup data, then change some of the settings.

  Load the measurement setup data from the mass storage memory, then change desired settings by SCPI programming.

- Set all settings.

  Set all settings for measurement setup by SCPI programming.

This section describes the following tasks:

- “To Set or Change 4155/56 Setup Data Values”
- “To Read 4155/56 Setup Data Values”

To load previously defined measurement setup data, refer to “Programming: File Operation” on page 2-47.

To Set or Change 4155/56 Setup Data Values

Send :PAGE subsystem commands that correspond to the setup data values that you want to change or set.

There is a command subsystem for each setup screen as shown in the following table. Each command subsystem has commands for setting the setup data of the corresponding setup screen.

Setup Screen	Command Subsystem
CHANNELS: CHANNEL DEFINITION	:PAGE:CHANnels[:CDEFinition]
CHANNELS: USER FUNCTION DEFINITION	:PAGE:CHANnels:UFUNction
CHANNELS: USER VARIABLE DEFINITION	:PAGE:CHANnels:UVARiable
MEASURE: SWEEP SETUP	:PAGE:MEASure[:SWEep]
MEASURE: SAMPLING SETUP	:PAGE:MEASure:SAMPling
MEASURE: PGU SETUP	:PAGE:MEASure:PGUSetup
MEASURE: MEASURE SETUP	:PAGE:MEASure:MSETup
MEASURE: OUTPUT SEQUENCE	:PAGE:MEASure:OSEQuence
DISPLAY: DISPLAY SETUP	:PAGE:DISPlay[:SETup]
DISPLAY: ANALYSIS SETUP	:PAGE:DISPlay:ANALysis
STRESS: CHANNEL DEFINITION	:PAGE:STRess:[CDEFinition]
STRESS: STRESS SETUP	:PAGE:STRess:SETup

Example

To load measurement setup data, then change the sweep start and stop values:

```
10    ASSIGN @Hp415x TO 800
20    !
30    OUTPUT @Hp415x;":MMEM:DEST INT"
40    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES','DISK'"
50    !
60    Swp_start=1
70    Swp_stop=10
80    !
90    OUTPUT @Hp415x;":PAGE:MEAS:VAR1:STAR ";Swp_start
100   OUTPUT @Hp415x;":PAGE:MEAS:VAR1:STOP ";Swp_stop
110   !
120   END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
40	Loads measurement setup data from diskette file `SWP.MES`.
90	Changes start value of VAR1.
100	Changes stop value of VAR1.

To Read 4155/56 Setup Data Values

To read setup data from the 4155/56 into an IBASIC variable, do as follows:

Send `:PAGE` subsystem query command that corresponds to setup data that you want to read.

Example

To load measurement setup data, then read the sweep start and stop values:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":MMEM:DEST INT"
40    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES','DISK'"
50    !
60    OUTPUT @Hp415x;":PAGE:MEAS:VAR1:STAR?"
70    ENTER @Hp415x;Swp_start
80    OUTPUT @Hp415x;":PAGE:MEAS:VAR1:STOP?"
90    ENTER @Hp415x;Swp_stop
100   !
110   PRINT "Sweep-start=";Swp_start,"Sweep-stop=";Swp_stop
120   !
130   END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
40	Loads measurement setup data from diskette file `SWP.MES`.
60 to 70	Reads start value of VAR1.
80 to 90	Reads stop value of VAR1.

Programming: Auto Analysis Setup

To set up the auto analysis function, use the :PAGE:DISP:ANAL subsystem commands.

- To draw a normal line:

  use the :PAGE:DISP:ANAL:LINE1|2:POIN commands.

- To draw a gradient line:

  use the :PAGE:DISP:ANAL:LINE1|2:POIN commands and the :PAGE:DISP:ANAL:LINE1|2:GRAD command.

- To draw a tangent line:

  use the :PAGE:DISP:ANAL:LINE1|2:TANG commands.

- To draw a regression line:

  use the :PAGE:DISP:ANAL:LINE1|2:POIN commands.

- To display a marker:

  use the :PAGE:DISP:ANAL:MARK commands.

For example, the following program defines the auto analysis condition to draw LINE1 between (0,0) and (5,0.001) for Y1 axis:

```
10      ASSIGN @Hp415x TO 717
20      !
30      OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:MODE NORM"
40      OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:YAX Y1"
50      !
60      OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:POIN1:MODE XY"
70      OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:POIN1:X '0'"
80      OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:POIN1:Y '0'"
90      !
100     OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:POIN2:MODE XY"
110     OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:POIN2:X '5'"
120     OUTPUT @Hp415x;":PAGE:DISP:ANAL:LINE1:POIN2:Y '1m'"
130     !
140     END
```

Figure 2-1 and Figure 2-2 shows the commands corresponding to the auto analysis setup fields. The figures are just example screen image.

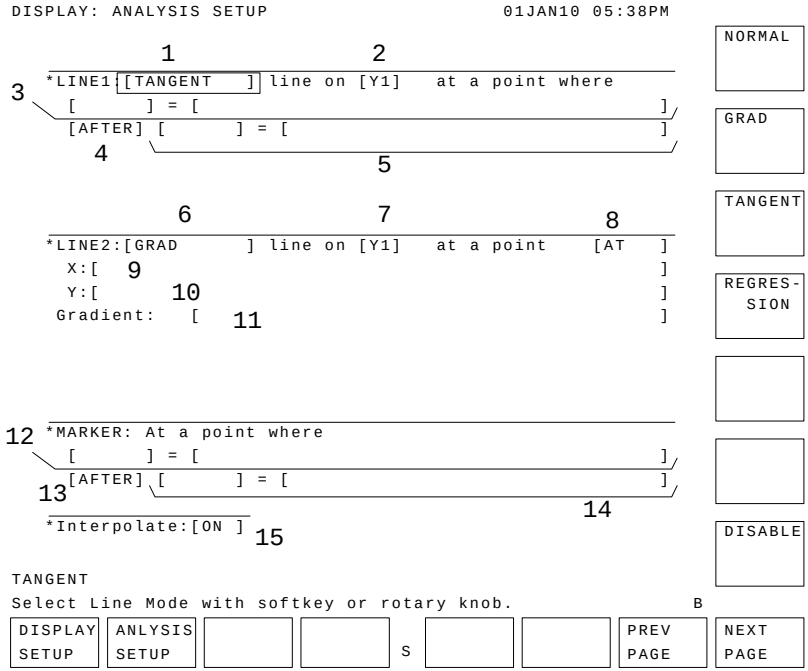
Figure 2-1 **Normal Line and Regression Line**

```
DISPLAY: ANALYSIS SETUP                          00JUL27 06:19PM
                                                                  NORMAL
                                                          1
   *LINE1:[NORMAL     ] line on [Y1] between a point [AT    ]
     X:[ 2                                                ]
     Y:[    3                                             ]      GRAD
    and a point  [WHERE] 4
 5   [       ] = [                                        ]
     [AFTER] [       ] = [                                ]  7   TANGENT
        6
   *LINE2:[REGRESSION] line on [Y1] between a point [WHERE] 8
 9   [       ] = [                                        ]
 10  [AFTER] [       ] = [                                ]  11  REGRES-
    and a point  [AT    ]  12                                      SION
     X:[ 13                                               ]
     Y:[     14                                           ]

   *MARKER: At a point where
     [       ] = [                                        ]
     [      ]

   *Interpolate:[ON ]                                            DISABLE

NORMAL
Select Line Mode with softkey or rotary knob.                B
DISPLAY  ANLYSIS                                  PREV     NEXT
SETUP    SETUP                    S                PAGE     PAGE
```

1 :DISP:ANAL:LINE1:POIN1:MODE
2 :DISP:ANAL:LINE1:POIN1:X
3 :DISP:ANAL:LINE1:POIN1:Y
4 :DISP:ANAL:LINE1:POIN2:MODE
5 :DISP:ANAL:LINE1:POIN2:POS
6 :DISP:ANAL:LINE1:POIN2:AFT:STAT
7 :DISP:ANAL:LINE1:POIN2:AFT

8 :DISP:ANAL:LINE2:POIN1:MODE
9 :DISP:ANAL:LINE2:POIN1:POS
10 :DISP:ANAL:LINE2:POIN1:AFT:STAT
11 :DISP:ANAL:LINE2:POIN1:AFT
12 :DISP:ANAL:LINE2:POIN2:MODE
13 :DISP:ANAL:LINE2:POIN2:X
14 :DISP:ANAL:LINE2:POIN2:Y

Figure 2-2 **Tangent Line, Gradient Line, and Marker**




```
1  :DISP:ANAL:LINE1:MODE
2  :DISP:ANAL:LINE1:YAX
3  :DISP:ANAL:LINE1:TANG:POS
4  :DISP:ANAL:LINE1:TANG:AFT:STAT
5  :DISP:ANAL:LINE1:TANG:AFT

6  :DISP:ANAL:LINE2:MODE
7  :DISP:ANAL:LINE2:YAX
8  :DISP:ANAL:LINE2:POIN1:MODE
9  :DISP:ANAL:LINE2:POIN1:X
10 :DISP:ANAL:LINE2:POIN1:Y
11 :DISP:ANAL:LINE2:GRAD

12 :DISP:ANAL:MARK:POS
13 :DISP:ANAL:MARK:AFT:STAT
14 :DISP:ANAL:MARK:AFT

15 :DISP:ANAL:INT
```

Programming: Measurement Execution

To execute a measurement, you can use :PAGE:SCONtrol subsystem commands.

This section describes the following tasks:

- “To Execute a Measurement”
- “To Force Stress”
- “To Start the Knob Sweep Function”
- “To Control Standby Units”
- “To Control the E5250A Low Leakage Switch Mainframe”

To Execute a Measurement

Send `:PAGE:SCONtrol[:MEASurement]:SINGle` command to the 4155C/4156C.

- If you would like to repeat measurements, send `:PAGE:SCONtrol[:MEASurement]:REPeat` command instead of :PAGE:SCONtrol[:MEASurement]:SINGle command.
- If you would like to append measurement, send `:PAGE:SCONtrol[:MEASurement]:APPend` command instead of :PAGE:SCONtrol[:MEASurement]:SINGle command.

Example 1

To execute a measurement after loading the measurement setup data:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":MMEM:DEST INT"
40    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
50    OUTPUT @Hp415x;":PAGE:SCON:SING"
60    !
70    END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
40	Loads measurement setup data from diskette file `SWP.MES`.
50	Executes measurement.

Example 2

To load two measurement setups from diskette and store them into internal memory, then execute the measurements sequentially:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":MMEM:DEST INT"
40    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'MEAS1.MES','DISK'"
50    OUTPUT @Hp415x;":MMEM:STOR:STAT 0,'MEM1.MES','MEMORY'"
60    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'MEAS2.MES','DISK'"
70    OUTPUT @Hp415x;":MMEM:STOR:STAT 0,'MEM2.MES','MEMORY'"
80    !
90    FOR I=1 TO 5
100     OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'MEM1.MES','MEMORY'"
110     OUTPUT @Hp415x;":PAGE:SCON:SING"
120     OUTPUT @Hp415x;"*OPC?"
130     ENTER @Hp415x;Complete
140     DISP "Analyze manually then press [Continue]"
150     PAUSE
160     !
170     OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'MEM2.MES','MEMORY'"
180     OUTPUT @Hp415x;":PAGE:SCON:SING"
190     OUTPUT @Hp415x;"*OPC?"
200     ENTER @Hp415x;Complete
210     DISP "Analyze manually and then press [Continue]"
220     PAUSE
230     !
240     IF I<5 THEN
250       DISP "Move to the next TEG and then press [Continue]"
260       PAUSE
270     END IF
280     !
290   NEXT I
300   !
310   END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
40 to 70	Loads two measurement setups from diskette, then stores them into internal memory.
100 to 130	Executes first measurement, then waits for measurement completion.
170 to 200	Executes second measurement, then waits for measurement completion.

To Force Stress

Send `:PAGE:SCONtrol:STRess[:STARt]` command to the 4155C/4156C.

Example 1

To force stress after loading the stress setup data:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":MMEM:DEST INT"
40    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'STRS.STR'"
50    OUTPUT @Hp415x;":PAGE:SCON:STR"
60    !
70    END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
40	Loads stress setup data from diskette file `STRS.STR`.
50	Executes stress forcing.

Example 2

To force stress, then execute sweep measurement:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":MMEM:DEST INT"
40    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'STRS.STR'"
50    OUTPUT @Hp415x;":PAGE:SCON:STR"
60    OUTPUT @Hp415x;"*OPC?"
70    ENTER @Hp415x;Complete
80    !
90    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
100   OUTPUT @Hp415x;":PAGE:SCON:SING"
110   !
120   END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
40	Loads stress setup data from diskette file `STRS.STR`.
50	Executes stress forcing.
60 to 70	Waits until stress forcing is completed.
90	Loads measurement setup data from diskette file `SWP.MES`.
100	Executes sweep measurement.

To Start the Knob Sweep Function

Send `:PAGE:SCONtrol:KSWeep[:STARt]` command

Example

To start the knob sweep function:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'MEM1.MES','MEMORY'"
40    OUTPUT @Hp415x;":PAGE:SCON:KSW"
50    !
60    END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Loads sweep setup data from internal memory file `MEM1`.
40	Starts knob sweep function.

To Control Standby Units

- To change the standby units from the idle state to the standby state:

  Send `:PAGE:SCONtrol:STANdby ON`.

  You cannot change which units are standby units after you execute this command. Standby units are units for which STBY is set to ON in the CHANNELS: CHANNELS DEFINITION screen.

- To change the standby units from the standby state to the idle state.

  Send `:PAGE:SCONtrol:STANdby OFF` to stop standby units.

Example

To set standby units to standby state (so standby value will be output before and after measurements), then after final measurement, change standby units to idle state:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":MMEM:DEST INT"
40    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP1.MES','DISK'"
50    OUTPUT @Hp415x;":PAGE:SCON:STAN ON"
60    OUTPUT @Hp415x;":PAGE:SCON:SING"
70    OUTPUT @Hp415x;"*OPC?"
80    ENTER @Hp415x;Complete
90    OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'MEAS1.DAT','DISK'"
100   !
110   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP2.MES','DISK'"
120   OUTPUT @Hp415x;":PAGE:SCON:SING"
130   OUTPUT @Hp415x;"*OPC?"
140   ENTER @Hp415x;Complete
150   OUTPUT @Hp415x;":PAGE:SCON:STAN OFF"
160   OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'MEAS2.DAT','DISK'"
170   END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
40	Loads measurement setup data from diskette file `SWP1.MES`.
50	The standby units specified in setup data start to output the standby value.
60	Executes measurement.
70 to 80	Waits for completion of measurement. After measurement, standby units output the standby value.
90	Stores measurement data onto a diskette.
110	Loads another measurement setup data from diskette file `SWP2.MES`. This setup data cannot change which units are the standby units.
120	Executes measurement.
130 to 140	Waits for completion of measurement. After measurement, standby units output the standby value.
150	Standby units stop standby output and change to idle state.
160	Stores measurement data onto a diskette.

To Control the E5250A Low Leakage Switch Mainframe

The 4155C/4156C can control the E5250A/E5252A switching matrix using the built-in IBASIC controller. To control the E5250A, connect the E5250A to the 4155C/4156C via GPIB, set the 4155C/4156C to SYSTEM CONTROLLER, and execute the following commands:

- :PAGE:CHANnels:MATrix:GPIB:ADDRess *address*

  This command sets the GPIB address of the E5250A.

- :PAGE:CHANnels:MATrix:CONTROL *onoff*

  This command enables or disables the remote control of the E5250A.

- :MMEM:LOAD:STATe 0,'*filename*.MAT','DISK'

  This command loads the E5250A setup file, and sends the setup to the E5250A.

- :PAGE:CHANnels:MATrix:CONNect

  This command sends the setup to the E5250A.

Example

Before executing the following example, set the GPIB address switch of the E5250A to 22.

```
10     ASSIGN @Hp415x TO 800
20    !
30     OUTPUT @Hp415x;":MMEM:DEST INT"
40     OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP1.MES','DISK'"
50    !
60     OUTPUT @Hp415x;":PAGE:CHAN:MAT:GPIB:ADDR 22"
70     OUTPUT @Hp415x;":PAGE:CHAN:MAT:CONTROL ON"
80     OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'CONN1.MAT','DISK'"
90     DISP "MODIFY E5250A SETUP. THEN PRESS Continue."
100    PAUSE
110    DISP ""
120    OUTPUT @Hp415x;":PAGE:CHAN:MAT:CONN"
130   !
140    OUTPUT @Hp415x;":PAGE:SCON:SING"
150    OUTPUT @Hp415x;"*OPC?"
160    ENTER @Hp415x;Complete
170    OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'RES1.DAT','DISK'"
180    END
```

Line Number	Description
10	Assigns an I/O path for controlling the 4155C/4156C.
30	Sets the built-in flexible disk drive as the mass storage device.
40	Loads the measurement setup data from the diskette file `SWP1.MES`.
60	Sets the E5250A GPIB address to 22.
70	Sets the E5250A control mode to ON.
80	Loads the E5250A setup data from the diskette file `CONN1.MAT`, and sends the setup to the E5250A.
90 to 100	Displays comments and pauses until the Continue key is pressed.
120	Applies the matrix connection information to the E5250A.
140	Executes a single measurement.
150 to 160	Waits for the completion of the measurement.
170	Stores the measurement data on a diskette as the file name `RES1.DAT`.

Programming: File Operation

This section describes how to use SCPI commands to store data to or load data from an internal memory, a diskette or the file system on the NFS server.

This section covers the following basic file operations:

- “To Store Setup Data”
- “To Store Measurement Data”
- “To Load Setup Data”
- “To Load Measurement Data”
- “To Store Spreadsheet Data”

Using NFS Server

If you use NFS server, you need to connect the 4155C/4156C to your LAN, and enter the following SCPI commands or set the following entry fields on the SYSTEM: MISCELLANEOUS screen before executing the file operation:

SCPI Command [a]	SYSTEM: MISCELLANEOUS Screen
:SYST:COMM:NET:SELF:NAME	NETWORK SETUP table HOST NAME
:SYST:COMM:NET:SELF:IPAD	NETWORK SETUP table IP ADDRESS
:SYST:COMM:NET:SELF:SNET	NETWORK SETUP table SUBNET MASK
:SYST:COMM:NET:SELF:GATE	NETWORK SETUP table GATEWAY
:SYST:COMM:NET:SELF:USER	NETWORK SETUP table USER ID
:SYST:COMM:NET:SELF:GROU	NETWORK SETUP table GROUP ID
:SYST:COMM:NET:FILE:NET:NAME	NETWORK DRIVE SETUP table LABEL
:SYST:COMM:NET:FILE:NET:IPAD	NETWORK DRIVE SETUP table IP ADDRESS
:SYST:COMM:NET:FILE:NET:DIR	NETWORK DRIVE SETUP table DIRECTORY
:SYST:COMM:NET:FILE:NET:SET	(same as selecting ADD softkey)

a. For details of the SCPI commands, refer to *SCPI Command Reference*.

To connect the 4155C/4156C to your LAN, refer to *User's Guide: General Information*.

To Store Setup Data

1. Send `:MMEMory:DESTination` command to the 4155C/4156C to specify the mass storage device.

   Then specify the command parameter:

   INT Selects the built-in flexible disk drive.

   NET*n* Selects the NFS server. *n*= 1, 2, 3 or 4.

2. Send `:MMEMory:STORe:STATe` command to the 4155C/4156C.

   a. Specify the first parameter to be 0. This parameter has no meaning for the 4155C/4156C, but is necessary for SCPI compatibility.

   b. Specify the second parameter:

      - For diskette or NFS server:
        File name with extension: `.MES` for measurement setup data or `.STR` for stress setup data.
      - For internal memory:
        Internal memory name (`MEM1`, `MEM2`, `MEM3`, or `MEM4`) with extension: `.MES` for measurement setup data or `.STR` for stress setup data.

   c. Specify the third parameter:

      - For diskette or NFS server: `DISK` (default)
      - For internal memory: `MEMORY`

Example

To store measurement setup data to a diskette file:

```
10    !
20    ASSIGN @Hp415x TO 717
30    !
40    OUTPUT @Hp415x;":MMEM:DEST INT"
50    OUTPUT @Hp415x;":MMEM:STOR:STAT 0,'SWP.MES','DISK'"
60    !
70    END
```

Line Number	Description
20	Assigns I/O path to control the 4155C/4156C.
30	Sets the mass storage device to the built-in flexible disk drive.
50	Stores measurement setup data to diskette file `SWP.MES`.

To Store Measurement Data

1. Send `:MMEMory:DESTination` command to the 4155C/4156C to specify the mass storage device.

   Specify the command parameter:

   INT Selects the built-in flexible disk drive.

   NET*n* Selects the NFS server. *n*= 1, 2, 3 or 4.

2. Send `:MMEMory:STORe:TRACe` command to the 4155C/4156C.

   a. Specify the first parameter to be `DEFault`. This parameter has no meaning for the 4155C/4156C, but is necessary for SCPI compatibility.

   b. Specify the second parameter:

      - For diskette or NFS server:

        File name with extension `.DAT`

      - For internal memory:

        Internal memory name (`MEM1`, `MEM2`, `MEM3`, or `MEM4`) with extension `.DAT`.

   c. Specify the third parameter:

      - For diskette or NFS server: `DISK` (default)
      - For internal memory: `MEMORY`

Example

To store measurement data to a diskette file:

```
10    !
20    ASSIGN @Hp415x TO 717
30    !
40    OUTPUT @Hp415x;":MMEM:DEST INT"
50    OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'SWP.DAT','DISK'"
60    !
70    END
```

Line Number	Description
20	Assigns I/O path to control the 4155C/4156C.
40	Sets the mass storage device to the built-in flexible disk drive.
50	Stores measurement data to diskette file `SWP.DAT`.

To Load Setup Data

1. Send `:MMEMory:DESTination` command to the 4155C/4156C to specify the mass storage device.

   Specify the command parameter:

   INT Selects the built-in flexible disk drive.

   NET*n* Selects the NFS server. *n*= 1, 2, 3 or 4.

2. Send `:MMEMory:LOAD:STATe` command to the 4155C/4156C.

   a. Specify the first parameter to be 0. This parameter has no meaning for the 4155C/4156C, but is necessary for SCPI compatibility.

   b. Specify the second parameter:

      - From diskette or NFS server:
        File name with extension: `.MES` for measurement setup data or `.STR` for stress setup data.
      - From internal memory:
        Internal memory name (`MEM1`, `MEM2`, `MEM3`, or `MEM4`) with extension: `.MES` for measurement setup data or `.STR` for stress setup data.

   c. Specify the third parameter:

      - From diskette or NFS server: `DISK` (default)
      - From internal memory: `MEMORY`

Example

To load measurement setup data from a diskette file:

```
10    !
20    ASSIGN @Hp415x TO 717
30    !
40    OUTPUT @Hp415x;":MMEM:DEST INT"
50    OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES','DISK'"
60    !
70    END
```

Line Number	Description
20	Assigns I/O path to control the 4155C/4156C.
40	Sets the mass storage device to the built-in flexible disk drive.
50	Loads measurement setup data from diskette file `SWP.MES`.

To Load Measurement Data

1. Send `:MMEMory:DESTination` command to the 4155C/4156C to specify the mass storage device.

   Specify the command parameter:

   INT Selects the built-in flexible disk drive.

   NET*n* Selects the NFS server. *n*= 1, 2, 3 or 4.

2. Send `:MMEMory:LOAD:TRACe` command to the 4155C/4156C.

   a. Specify the first parameter to be `DEFault`. This file has no meaning for the 4155C/4156C, but is necessary for SCPI compatibility.

   b. Specify the second parameter:

      - From diskette or NFS server:
        File name with extension `.DAT`
      - From internal memory:
        Internal memory name (`MEM1`, `MEM2`, `MEM3`, or `MEM4`) with extension `.DAT`.

   c. Specify the third parameter:

      - From diskette or NFS server: `DISK` (default)
      - From internal memory: `MEMORY`

Example

To load measurement data from a diskette file:

```
10    !
20    ASSIGN @Hp415x TO 717
30    !
40    OUTPUT @Hp415x;":MMEM:DEST INT"
50    OUTPUT @Hp415x;":MMEM:LOAD:TRAC DEF,'SWP.DAT','DISK'"
60    !
70    END
```

Line Number	Description
20	Assigns I/O path to control the 4155C/4156C.
40	Sets the mass storage device to the built-in flexible disk drive.
50	Loads measurement data from diskette file `SWP.DAT`.

To Store Spreadsheet Data

1. Send `:MMEMory:DESTination` command to the 4155C/4156C to specify the mass storage device.

   Specify the command parameter:

   INT Selects the built-in flexible disk drive.

   NET*n* Selects the NFS server. *n*= 1, 2, 3 or 4.

2. Send `:MMEMory:STORe:SSHeet:DELimiter` command to the 4155C/4156C to specify the delimiter; SPACe, TAB, or COMMa.

3. Send `:MMEMory:STORe:SSHeet:LINDex` command to the 4155C/4156C to specify the first data index and the last data index for data output. The MINimum and MAXimum are also available for the data index.

4. Send `:MMEMory:STORe:SSHeet:SMARK` command to the 4155C/4156C to specify the string mark; NONE, DQUote (double quotes), or SQUote (single quotes).

5. Send `:MMEMory:STORe:SSHeet:UNIT` command to the 4155C/4156C to set the unit ON or OFF. If you set it to ON, the measured data will be saved with the unit.

6. Send `:MMEMory:STORe:SSHeet` command to the 4155C/4156C to specify the file name and save the spreadsheet data. Then use the single quotes to specify the file name.

Example

The following example stores a spreadsheet data to a diskette file. The example uses a variable to specify the file name.

```
10    !
20    ASSIGN @Hp415x TO 717
30    DIM A$[8]  !Max 8 characters for diskette file name
40    A$="DATA1" !File Name
50    !
60    OUTPUT @Hp415x;":MMEM:DEST INT"
70    OUTPUT @Hp415x;":MMEM:STOR:SSH:DEL COMM"
80    OUTPUT @Hp415x;":MMEM:STOR:SSH:LIND 1,MAX"
90    OUTPUT @Hp415x;":MMEM:STOR:SSH:SMARK DQU"
100   OUTPUT @Hp415x;":MMEM:STOR:SSH:UNIT ON"
110   OUTPUT @Hp415x;":MMEM:STOR:SSH ";CHR$(39)&A$&CHR$(39)
120   !CHR$(39) should be used instead of a single quote
130   END
```

Line Number	Description
20	Assigns I/O path to control the 4155C/4156C.
30	Declares the maximum number of the characters for the file name.
40	Defines the file name. For example, `DATA1`.
60	Sets the mass storage device to the built-in flexible disk drive.
70	Sets the comma as the delimiter.
80	Sets the minimum data index to 1 and the maximum index to MAX that means the maximum index of the measured data.
90	Sets the double quotes as the string mark.
100	Enables to save the data with the unit.
110	Stores a spreadsheet data to the diskette file `DATA1.TXT`. The file extention TXT is automatically set.

Programming: Data Transfer

This section describes the data transfer between a program and the 4155C/4156C.

The following programming tasks are described in this section:

- “To Read 4155/56 Measurement Data”
- “To Transfer Data to 4155C/4156C (Using User Variable)”

To Read 4155/56 Measurement Data

Send `:DATA?` query command to get data variable values (output data, measurement data, user function values) or read-out function values from 4155/56 to IBASIC variables.

Example 1

To get measurement data, then store it in a data array:

```
10    DIM I3(1:501)
20    !
30    ASSIGN @Hp415x TO 717
40    !
50    OUTPUT @Hp415x;":FORM:DATA ASC"
60    !
70    OUTPUT @Hp415x;":DATA? 'I3'"
80    ENTER @Hp415x;I3(*)
90    !
100    END
```

Line Number	Description
30	Assigns I/O path to control the 4155C/4156C.
50	Specifies ASCII data transfer format.
70 to 80	Gets the values of data variable `I3`.

Example 2

To get slope of LINE1 for Y2 axis curve on GRAPH/LIST: GRAPHICS screen:

```
10    ASSIGN @Hp415x TO 717
20    !
30    OUTPUT @Hp415x;":DATA? '@L1G2'"
40    ENTER @Hp415x;Slope
50    !
60    PRINT Slope
70    END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30 to 40	Gets slope of LINE1 for Y2 axis curve on GRAPH/LIST: GRAPHICS screen.

To Transfer Data to 4155C/4156C (Using User Variable)

To transfer a user variable to the 4155C/4156C, use DATA|TRACe subsystem commands. A user variable consists of a name, unit, and numeric data.

Transferred user variable data can be used like other data variables in the 4155C/4156C. You can perform calculations between measurement results and transferred data, plot transferred data on GRAPH/LIST: GRAPHICS screen, or list transferred data on GRAPH/LIST: LIST screen.

To transfer numeric data to the 4155C/4156C:

1. Define the data transfer format by using :FORMat[:DATA] command.
   - For ASCII data transfer format, send `:FORM ASC`.
   - For REAL 64-bit length data transfer format, send `:FORM REAL,64`.
   - For REAL 32-bit length data transfer format, send `:FORM REAL,32`.
2. For REAL data transfer format, define byte order by using :FORMat:BORDer command.
   - For normal order, send `:FORM:BORD NORM`.
   - For swapped order, send `:FORM:BORD SWAP`.
3. Define name of the user variable, unit (optional), and number of numeric data by using the :PAGE:CHANnels:UVARiable:DEFine command.

   You can also define these parameters by using the :DATA:DEFine and :DATA:UNIT command.

   If user variable is already defined, you do not have to perform this step.
4. Transfer data by using :DATA|:TRACe:[:DATA] command.

Example 1

To transfer data array by using ASCII data transfer format:

```
10   DIM Uvar1(1:5)
20   !
30   ASSIGN @Hp415x TO 717
40   !
50   Uvar1(1)=1.0
60   Uvar1(2)=1.1
70   Uvar1(3)=1.2
80   Uvar1(4)=1.3
90   Uvar1(5)=1.4
100  !
110  OUTPUT @Hp415x;":FORM:DATA ASC"
120  OUTPUT @Hp415x;":PAGE:CHAN:UVAR:DEF 'UVAR1','V',5"
130  OUTPUT @Hp415x;":TRAC 'UVAR1',";Uvar1(*)
140  !
150  END
```

Line Number	Description
30	Assigns I/O path to control the 4155C/4156C.
110	Specifies ASCII data transfer format.
120	Defines user variable.
130	Transfers user variable.

Example 2

To transfer data array by using REAL 64-bit data transfer format:

```
10   DIM Uvar1(1:101)
20   INTEGER I
30   !
40   ASSIGN @Hp415x TO 717
50   ASSIGN @Form_off TO 717;FORMAT OFF
60   !
70   FOR I=1 TO 101
80    Uvar1(I)=SQRT(I)
90   NEXT I
100  !
110  OUTPUT @Hp415x;":FORM REAL,64"
120  OUTPUT @Hp415x;":FORM:BORD NORM"
130  OUTPUT @Hp415x;":PAGE:CHAN:UVAR:DEF 'UVAR1','',101"
140  OUTPUT @Hp415x;":TRAC 'UVAR1',#0";
150  OUTPUT @Form_off;Uvar1(*),END
160  !
170  END
```

Line Number	Description
40	Assigns I/O path to control the 4155C/4156C.
50	Assigns I/O path to transfer data.
110 to 120	Specifies REAL 64 bit data transfer format.
130	Defines a user variable.
140 to 150	Transfers user variable.

Example 3

To transfer data, then display plot of transferred data and measurement results:

```
10   DIM Uvar1(1:101)
20   !
30   ASSIGN @Hp415x TO 717
40   !
50   FOR I=1 TO 101
60    Uvar1(I)=SQRT(I)
70   NEXT I
80   !
90   OUTPUT @Hp415x;":MMEM:DEST INT"
100  OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
110  OUTPUT @Hp415x;":PAGE:SCON:SING"
120  OUTPUT @Hp415x;"*OPC?"
130  ENTER @Hp415x;Complete
140  !
150  OUTPUT @Hp415x;":FORM ASC"
160  OUTPUT @Hp415x;":DATA:DEF 'UVAR1',101"
170  OUTPUT @Hp415x;":DATA:UNIT 'UVAR1','V'"
180  OUTPUT @Hp415x;":DATA 'UVAR1',";Uvar1(*)
190  !
200  OUTPUT @Hp415x;":PAGE:DISP:GRAP:Y2:NAME 'UVAR1'"
210  OUTPUT @Hp415x;":PAGE:GLIS"
220  END
```

Line Number	Description
30	Assigns I/O path to control the 4155C/4156C.
90	Sets the mass storage device to the built-in flexible disk drive.
100	Loads measurement setup data from diskette file `SWP.MES`.
110	Executes measurement.
120 to 130	Waits for measurement completion.
150	Specifies ASCII data transfer format.
160	Defines user variable.
170	Defines unit of user variable.
180	Transfers user variable.
200	Sets user variable to Y2 axis of graph.
210	Displays GRAPH/LIST: GRAPHICS screen.

Programming: Print/Plot Operation

For the print/plot operation, you can use :HCOPy subsystem commands.

This section describes the following tasks:

- “To Output Setup Data to Printer/Plotter”
- “To Output Graphics Result Data to Printer/Plotter”
- “To Output List Results Data to Printer/Plotter”
- “To Dump Screen Image to Printer/Plotter”
- “To Save Print/Plot Data to a File”
- “To Save Hardcopy Image to a File”

Before doing print/plot operation

Before performing above tasks, the following print or plot settings must be set interactively or by remote commands.

We recommend that you save the following settings in a file, then load it before printing or plotting.

1. Printer information

Setting Parameter	Command
destination	:HCOP:DEST
color mode	:HCOP:DEV:CMOD
control language	:HCOP:DEV:LANG
resolution (PCL)	:HCOP:DEV:RES

2. Output Items

Item	Command
Title of the print or plot out	:HCOP:ITEM:ANN:STAT
User defined comment for screen group	:HCOP:ITEM:ANN2:STAT
Present date and time of the built-in clock	:HCOP:ITEM:TDST:STAT
Page number of the print or plot out	:HCOP:ITEM:PNUM:STAT
User defined comment for print or plot out	:HCOP:ITEM:LAB:STAT
Graphics plot curve	:HCOP:ITEM:TRAC:STAT
Frame and grid	:HCOP:ITEM:TRAC:GRAT:STAT
Marker, cursor, and data variable coordinate fields, and line parameters (gradients and intercepts)	:HCOP:ITEM:TEXT:STAT
Names, units, and scale of the graph axis	:HCOP:ITEM:TEXT2:STAT

If you use GPIB printer/plotter

1. Set the GPIB address:

Item	Command
GPIB address of printer/plotter	:SYST:COMM:GPIB:RDEV:ADDR

2. To use built-in IBASIC:

   Set "`4155C/56C is`" field on the SYSTEM: MISCELLANEOUS screen to SYSTEM CONTROLLER.

If you use a remote printer

1. If you use a remote printer via your print server, you need to connect the 4155C/4156C to your LAN. To connect the 4155C/4156C to your LAN, refer to *User's Guide: General Information*.
2. Enter the following SCPI commands or set the following entry fields on the SYSTEM: MISCELLANEOUS screen before printing out:

SCPI Command [a]	SYSTEM: MISCELLANEOUS Screen
:SYST:COMM:SELF:NAME	NETWORK SETUP table HOST NAME
:SYST:COMM:SELF:IPAD	NETWORK SETUP table IP ADDRESS
:SYST:COMM:SELF:SNET	NETWORK SETUP table SUBNET MASK
:SYST:COMM:SELF:GATE	NETWORK SETUP table GATEWAY
:SYST:COMM:SELF:USER	NETWORK SETUP table USER ID
:SYST:COMM:SELF:GROU	NETWORK SETUP table GROUP ID
:SYST:COMM:PRIN:NET:NAME	NETWORK PRINTER SETUP table PRINTER
:SYST:COMM:PRIN:NET:IPAD	NETWORK PRINTER SETUP table IP ADDRESS
:SYST:COMM:PRIN:NET:TEXT	NETWORK PRINTER SETUP table TEXT OUT
:SYST:COMM:PRIN:NET:GRAP	NETWORK PRINTER SETUP table GRAPH OUT
:SYST:COMM:PRIN:NET:TYPE	NETWORK PRINTER SETUP table SERVER TYPE
:SYST:COMM:PRIN:NET:SET	(same as selecting ADD softkey)
:SYST:NTMO	SYSTEM SETUP table LP TIMEOUT

a. For details of the SCPI commands, refer to *SCPI Command Reference*.

To Output Setup Data to Printer/Plotter

1. If you want to output print/plot comment, enter comment by using :HCOPy:ITEM:LABel:TEXT command.
2. Specify the range of setup data to print/plot by sending `:HCOPy:OPAGe` command.
   - To print/plot present *screen* setup data, send `:HCOPy:OPAGe CURRent`
   - To print/plot present *screen group* setup data, send `:HCOPy:OPAGe GROup`
   - To print/plot *all* setup data, send `:HCOPy:OPAGe ALL`
3. Display the screen that you want to print/plot by using the appropriate command:

Screen	Command
CHANNELS: CHANNEL DEFINITION	:PAGE:CHAN
CHANNELS: USER FUNCTION DEFINITION	:PAGE:CHAN:UFUN
CHANNELS: USER VARIABLE DEFINITION	:PAGE:CHAN:UVAR
MEASURE: SWEEP SETUP	:PAGE:MEAS
MEASURE: SAMPLING SETUP	:PAGE:MEAS:SAMP
MEASURE: PGU SETUP	:PAGE:MEAS:PGUS
MEASURE: MEASURE SETUP	:PAGE:MEAS:MSET
MEASURE: OUTPUT SEQUENCE	:PAGE:MEAS:OSEQ
DISPLAY: DISPLAY SETUP	:PAGE:DISP
DISPLAY: ANALYSIS SETUP	:PAGE:DISP:ANAL
STRESS: CHANNEL DEFINITION	:PAGE:STR
STRESS: STRESS SETUP	:PAGE:STR:SET
STRESS: STRESS FORCE	:PAGE:STR:FORC

If you print/plot from built-in IBASIC, change display mode to All Instrument or IBASIC Status by sending :DISPlay[:WINDow]:ALLocation command.

4. Print/plot the setup data by sending `:HCOPy` command.

   If you print/plot from an external computer using a GPIB peripheral, pass Active Controller capability to the 4155C/4156C after sending `:HCOPy` command because the 4155C/4156C requires Active Controller capability to print.

Refer to the following examples.

Example 1

The example loads a sweep setup file, then prints setup data of the MEASURE: SWEEP SETUP screen. The program is for an external computer.

```
10   ASSIGN @Hp415x TO 717
20   CONTROL 7,3;21
30   !
40   OUTPUT @Hp415x;"*RST"
50   OUTPUT @Hp415x;"*PCB 21"
60   !
70   OUTPUT @Hp415x;":MMEM:DEST INT"
80   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
90   OUTPUT @Hp415x;":HCOP:ITEM:PNUM:STAT OFF"
100  OUTPUT @Hp415x;":HCOP:ITEM:LAB:TEXT 'This is an example'"
       :
       :
```

for line number 110 and above, see next page

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from external computer.
20	Sets the GPIB address of external computer. This will be necessary to return Active Controller capability from the 4155C/4156C back to the external computer.
40	Resets the 4155C/4156C.
50	Specifies to pass Active Controller capability back to external computer after printing is completed.
70	Sets the mass storage device to the built-in flexible disk drive.
80	Loads measurement setup data from diskette file `SWP.MES`.
90	Specifies to not print the page number.
100	Defines a print/plot comment.

for line number 100 and below, see previous page

```
        :
        :
110  OUTPUT @Hp415x;":HCOP:DEST RDEV"
120  OUTPUT @Hp415x;":HCOP:OPAG CURR"
130  !
140  OUTPUT @Hp415x;":PAGE:MEAS"
150  !
160  OUTPUT @Hp415x;":HCOP"
170  REPEAT
180    OUTPUT @Hp415x;"*ESR?"
190    ENTER @Hp415x;Event_status
200  UNTIL BIT(Event_status,1)
210  !
220  PASS CONTROL @Hp415x
230  DISP "Printing"
240  REPEAT
250    STATUS 7,6;Hpib_status
260  UNTIL BIT(Hpib_status,6)
270  DISP "Done"
280  END
```

Line Number	Description
110	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
120 to 140	Specifies to print/plot the setup data of the MEASURE: SWEEP SETUP screen.
160 to 200	Sends print command and waits for Active Controller request from the 4155C/4156C.
220	Passes Active Controller capability to the 4155C/4156C, then the 4155C/4156C starts printing.
240 to 260	Waits until printing is complete.

Example 2

The example loads a sweep setup file, then prints setup data of the MEASURE: SWEEP SETUP screen. The program is for built-in IBASIC.

```
10   ASSIGN @Hp415x TO 800
20   !
30   OUTPUT @Hp415x;"*RST"
40   !
50   OUTPUT @Hp415x;":MMEM:DEST INT"
60   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES','DISK'"
70   OUTPUT @Hp415x;":HCOP:ITEM:PNUM:STAT OFF"
80   OUTPUT @Hp415x;":HCOP:ITEM:LAB:TEXT 'This is an example'"
90   OUTPUT @Hp415x;":HCOP:DEST RDEV"
100  OUTPUT @Hp415x;":HCOP:OPAG CURR"
110  !
120  OUTPUT @Hp415x;":DISP:ALL INST"
130  OUTPUT @Hp415x;":PAGE:MEAS"
140  !
150  OUTPUT @Hp415x;":HCOP"
160  DISP "Printing"
170  OUTPUT @Hp415x;"*OPC?"
180  ENTER @Hp415x;Complete
190  DISP "Done"
200  !
210  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from built-in IBASIC.
30	Resets the 4155C/4156C.
50	Sets the mass storage device to the built-in flexible disk drive.
60	Loads measurement setup data from diskette file `SWP.MES`.
70	Specifies to not print the page number.
80	Defines a print/plot comment.
90	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
100 to 130	Specifies to print/plot the setup data of the MEASURE: SWEEP SETUP screen.
150	Starts printing.
170 and 180	Waits until printing is complete.

To Output Graphics Result Data to Printer/Plotter

1. If you want to output print/plot comment, enter comment by using :HCOPy:ITEM:LABel:TEXT command.
2. Display GRAPH/LIST: GRAPHICS screen by using :PAGE:GLISt:[:GRAPhics] command.

   If you print/plot from built-in IBASIC, change display mode to All Instrument or IBASIC Status display mode by sending :DISPlay[:WINDow]:ALLocation command.
3. Execute print/plot by using :HCOPy command.

   If you print/plot from an external computer using a GPIB peripheral, pass Active Controller capability to the 4155C/4156C after sending `:HCOPy` command because the 4155C/4156C requires Active Controller capability to print.

Refer to the following examples.

Example 1

The example loads a sweep setup file, executes measurement, then prints measurement results of GRAPH/LIST: GRAPHICS screen. The program is for an external computer.

```
10   ASSIGN @Hp415x TO 717
20   CONTROL 7,3;21
30   !
40   OUTPUT @Hp415x;"*RST"
50   OUTPUT @Hp415x;"*PCB 21"
60   !
70   OUTPUT @Hp415x;":MMEM:DEST INT"
80   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
90   !
100  OUTPUT @Hp415x;":PAGE:SCON:SING"
110  OUTPUT @Hp415x;"*OPC?"
120  ENTER @Hp415x;Complete
130  !
140  OUTPUT @Hp415x;":HCOP:DEST RDEV"
150  !
160  OUTPUT @Hp415x;":PAGE:GLIS"
170  !
180  OUTPUT @Hp415x;":HCOP"
190  REPEAT
200    OUTPUT @Hp415x;"*ESR?"
210    ENTER @Hp415x;Event_status
220  UNTIL BIT(Event_status,1)
230  !
240  PASS CONTROL @Hp415x
250  DISP "Printing"
260  REPEAT
270    STATUS 7,6;Hpib_status
280  UNTIL BIT(Hpib_status,6)
290  DISP "Done"
300  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from external computer.
20	Sets the GPIB address of external computer. This will be necessary to return Active Controller capability from the 4155C/4156C back to the external computer.
40	Resets the 4155C/4156C.
50	Specifies to pass Active Controller capability back to external computer after printing is completed.
70	Sets the mass storage device to the built-in flexible disk drive.
80	Loads measurement setup data from diskette file `SWP.MES`.
100 to 120	Executes measurement and waits until completed.
140	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
160	Changes screen to GRAPH/LIST: GRAPHICS screen.
180 to 220	Sends print command and waits for Active Controller request from the 4155C/4156C.
240	Passes Active Controller capability to the 4155C/4156C, then the 4155C/4156C starts printing.
260 to 280	Waits until printing is complete.

Example 2

The example loads a sweep setup file, executes measurement, then prints measurement results of GRAPH/LIST: GRAPHICS screen. The program is for built-in IBASIC.

```
10   ASSIGN @Hp415x TO 800
20   !
30   OUTPUT @Hp415x;"*RST"
40   !
50   OUTPUT @Hp415x;":MMEM:DEST INT"
60   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
70   !
80   OUTPUT @Hp415x;":PAGE:SCON:SING"
90   OUTPUT @Hp415x;"*OPC?"
100  ENTER @Hp415x;Complete
110  !
120  OUTPUT @Hp415x;":HCOP:DEST RDEV"
130  !
140  OUTPUT @Hp415x;":DISP:ALL INST"
150  OUTPUT @Hp415x;":PAGE:GLIS"
160  !
170  OUTPUT @Hp415x;":HCOP"
180  DISP "Printing"
190  OUTPUT @Hp415x;"*OPC?"
200  ENTER @Hp415x;Complete
210  DISP "Done"
220  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from built-in IBASIC.
30	Resets the 4155C/4156C.
50	Sets the mass storage device to the built-in flexible disk drive.
60	Loads measurement setup data from diskette file `SWP.MES`.
80 to 100	Executes measurement and waits until complete.
120	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
140 to 150	Changes screen to GRAPH/LIST: GRAPHICS screen.
170 to 200	Starts printing and waits until completion.

To Output List Results Data to Printer/Plotter

1. Specify the range of measurement results to output by using :HCOPy:LINDex command.
2. If you want to output print/plot comment, enter comment by using :HCOPy:ITEM:LABel:TEXT command.
3. Display GRAPH/LIST: LIST screen by using :PAGE:GLISt:LIST command.

   If you print/plot from built-in IBASIC, change display mode to All Instrument or IBASIC Status display mode by sending :DISPlay[:WINDow]:ALLocation command.
4. Execute print/plot by using :HCOPy command.

   If you print/plot from an external computer using a GPIB peripheral, pass Active Controller capability to the 4155C/4156C after sending `:HCOPy` command because the 4155C/4156C requires Active Controller capability to print.

Refer to the following examples.

Example 1

The example loads a sweep setup file, executes measurement, then prints measurement results of GRAPH/LIST: LIST screen. The program is for an external computer.

```
10   ASSIGN @Hp415x TO 717
20   CONTROL 7,3;21
30   !
40   OUTPUT @Hp415x;"*RST"
50   OUTPUT @Hp415x;"*PCB 21"
60   !
70   OUTPUT @Hp415x;":MMEM:DEST INT"
80   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
90   !
100  OUTPUT @Hp415x;":PAGE:SCON:SING"
110  OUTPUT @Hp415x;"*OPC?"
120  ENTER @Hp415x;Complete
130  !
140  OUTPUT @Hp415x;":HCOP:DEST RDEV"
150  OUTPUT @Hp415x;":HCOP:LIND MAX"
160  !
170  OUTPUT @Hp415x;":PAGE:GLIS:LIST"
180  !
190  OUTPUT @Hp415x;":HCOP"
200  REPEAT
210    OUTPUT @Hp415x;"*ESR?"
220    ENTER @Hp415x;Event_status
230  UNTIL BIT(Event_status,1)
240  !
250  PASS CONTROL @Hp415x
260  DISP "Printing"
270  REPEAT
280    STATUS 7,6;Hpib_status
```

```
290  UNTIL BIT(Hpib_status,6)
300  DISP "Done"
310  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from external computer.
20	Sets the GPIB address of external computer. This will be necessary to return Active Controller capability from the 4155C/4156C back to the external computer.
40	Resets the 4155C/4156C.
50	Specifies to pass Active Controller capability back to external computer after printing is completed.
70	Sets the mass storage device to the built-in flexible disk drive.
80	Loads measurement setup data from diskette file `SWP.MES`.
100 to 120	Executes measurement and waits until completed.
140	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
150	Sets the range of list results to be output.
170	Changes screen to GRAPH/LIST: LIST screen.
190 to 230	Sends print command and waits for Active Controller request from the 4155C/4156C.
250	Passes Active Controller capability to the 4155C/4156C, then the 4155C/4156C starts printing.
270 and 290	Waits until completion of printing.

Example 2

The example loads a sweep setup file, executes measurement, then prints measurement results of GRAPH/LIST: LIST screen. The program is for built-in IBASIC.

```
10   ASSIGN @Hp415x TO 800
20   !
30   OUTPUT @Hp415x;"*RST"
40   !
50   OUTPUT @Hp415x;":MMEM:DEST INT"
60   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
70   !
80   OUTPUT @Hp415x;":PAGE:SCON:SING"
90   OUTPUT @Hp415x;"*OPC?"
100  ENTER @Hp415x;Complete
110  !
120  OUTPUT @Hp415x;":HCOP:DEST RDEV"
130  OUTPUT @Hp415x;":HCOP:LIND MAX"
140  !
150  OUTPUT @Hp415x;":DISP:ALL INST"
160  OUTPUT @Hp415x;":PAGE:GLIS:LIST"
170  !
180  OUTPUT @Hp415x;":HCOP"
190  DISP "Printing"
200  OUTPUT @Hp415x;"*OPC?"
210  ENTER @Hp415x;Complete
220  DISP "Done"
230  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from built-in IBASIC.
30	Resets the 4155C/4156C.
50	Sets the mass storage device to the built-in flexible disk drive.
60	Loads measurement setup data from diskette file `SWP.MES`.
80 to 100	Executes measurement and waits until completion.
120	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
130	Sets the range of list results to be output.
150 to 160	Changes screen to GRAPH/LIST: LIST screen.
180 to 210	Starts printing and waits until completion.

To Dump Screen Image to Printer/Plotter

1. Display the screen to be dumped.
2. Execute print/plot by using :HCOPy:SDUMp command.

   If you print/plot from an external computer using a GPIB peripheral, pass Active Controller capability to the 4155C/4156C after sending `:HCOPy:SDUMp` command because the 4155C/4156C requires Active Controller capability to print.

Refer to the following example.

Example 1

The example loads a sweep setup file, executes measurement, displays GRAPH/LIST: GRAPHICS screen, then dumps screen image of GRAPH/LIST: GRAPHICS screen to printer/plotter. The program is for an external computer.

```
10   ASSIGN @Hp415x TO 717
20   CONTROL 7,3;21
30   !
40   OUTPUT @Hp415x;"*RST"
50   OUTPUT @Hp415x;"*PCB 21"
60   !
70   OUTPUT @Hp415x;":MMEM:DEST INT"
80   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
90   !
100  OUTPUT @Hp415x;":PAGE:SCON:SING"
110  OUTPUT @Hp415x;"*OPC?"
120  ENTER @Hp415x;Complete
130  !
140  OUTPUT @Hp415x;":HCOP:DEST RDEV"
150  !
160  OUTPUT @Hp415x;":PAGE:GLIS"
170  !
180  OUTPUT @Hp415x;":HCOP:SDUM"
190  REPEAT
200    OUTPUT @Hp415x;"*ESR?"
210    ENTER @Hp415x;Event_status
220  UNTIL BIT(Event_status,1)
230  !
240  PASS CONTROL @Hp415x
250  DISP "Printing"
260  REPEAT
270    STATUS 7,6;Hpib_status
280  UNTIL BIT(Hpib_status,6)
290  DISP "Done"
300  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from external computer.
20	Sets the GPIB address of external computer. This will be necessary to return Active Controller capability from the 4155C/4156C back to the computer.
40	Resets the 4155C/4156C.
50	Specifies to pass Active Controller capability back to external computer after printing is completed.
70	Sets the mass storage device to the built-in flexible disk drive.
80	Loads measurement setup data from diskette file `SWP.MES`.
100 to 120	Executes measurement and waits until completed.
140	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
160	Changes screen to GRAPH/LIST: GRAPHICS screen.
180 to 220	Sends screen dump command and waits for Active Controller request from the 4155C/4156C.
240	Passes Active Controller capability to the 4155C/4156C, then the 4155C/4156C starts printing.
260 and 280	Waits until printing is complete.

Example 2

The example loads a sweep setup file, executes measurement, displays GRAPH/LIST: GRAPHICS screen, then dumps screen image of GRAPH/LIST: GRAPHICS screen to printer/plotter. The program is for built-in IBASIC.

```
10   ASSIGN @Hp415x TO 800
20   !
30   OUTPUT @Hp415x;"*RST"
40   !
50   OUTPUT @Hp415x;":MMEM:DEST INT"
60   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
70   !
80   OUTPUT @Hp415x;":PAGE:SCON:SING"
90   OUTPUT @Hp415x;"*OPC?"
100  ENTER @Hp415x;Complete
110  !
120  OUTPUT @Hp415x;":DISP:ALL INST"
130  OUTPUT @Hp415x;":PAGE:GLIS"
140  !
150  OUTPUT @Hp415x;":HCOP:DEST RDEV"
160  OUTPUT @Hp415x;":HCOP:SDUM"
170  OUTPUT @Hp415x;"*OPC?"
180  ENTER @Hp415x;Complete
190  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C from built-in IBASIC.
30	Resets the 4155C/4156C.
50	Sets the mass storage device to the built-in flexible disk drive.
60	Loads measurement setup data from diskette file `SWP.MES`.
80 to 100	Executes measurement and waits until completion.
120 to 130	Displays GRAPH/LIST: GRAPHICS screen.
150	Selects GPIB interface. If parallel interface, change the parameter to "PAR".
160 to 180	Starts printing and waits until completion.

To Save Print/Plot Data to a File

1. Use the :HCOP:ITEM subsystem commands to add/select the print/plot output items. See “Before doing print/plot operation” on page 2-60.
2. Use the :PAGE command to specify the screen to print/plot.
3. Use the :HCOP:ITEM:ALL:DATA? command to return the all output data. Or use the :HCOP:DATA? command to return the output data selected by the :HCOP:ITEM subsystem commands.

Example

The following program loads a sweep setup file, executes measurement, and puts the print/plot output data of the GRAPH/LIST: LIST screen into the 4155C/4156C output buffer. Then the computer reads the output data, and saves it to a file named “SAMPLE1.ASC”. The following example program saves the print/plot output data that contains the header lines (11 lines) and the measurement data lines (51 lines) displayed on the GRAPH/LIST: LIST screen.

```
10   INTEGER Nop,Head
20   Head=11  ! Number of header lines
30   Nop=51   ! Number of data lines
40   DIM A$[100]
50   DIM Get_file$[8]
60   Get_file$="SWP.MES" ! Setup file for measurement
70   File$="SAMPLE1.ASC" ! Data file to be saved
80   !
90   ASSIGN @Hp415x TO 717
100  OUTPUT @Hp415x;"*RST"
110  OUTPUT @Hp415x;":MMEM:DEST INT"
120  OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,";CHR$(39)&Get_file$&CHR$(
39)
130  OUTPUT @Hp415x;":PAGE:SCON:SING"
140  OUTPUT @Hp415x;"*OPC?"
150  ENTER @Hp415x;Complete
160  !
170  !OUTPUT @Hp415x;":HCOP:ITEM:LAB:TEXT 'Measurement Data'"
180  OUTPUT @Hp415x;":PAGE:GLIS:LIST" ! LIST screen
190  !OUTPUT @Hp415x;":HCOP:DATA?"
200  OUTPUT @Hp415x;":HCOP:ITEM:ALL:DATA?"
210  !
220  CREATE File$,1
230  ASSIGN @Io TO File$;FORMAT ON
240  FOR I=1 TO Nop+Head
250    ENTER @Hp415x;A$
260    OUTPUT @Io;A$
270  NEXT I
280  ASSIGN @Io TO *
290  !
300  END
```

Line Number	Description
20	Sets the number of header lines for the print/plot output of the GRAPH/LIST: LIST screen. The lines will be saved to a file.
30	Sets the number of lines for the measurement data displayed on the LIST screen. The lines will be saved to a file.
40 to 50	Declares the dimension of the strings A$ and Get_file$.
60	Specifies the setup data file used for measurement.
70	Sets the name of the print/plot output data file to be saved.
90	Assigns I/O path to control the 4155C/4156C.
100	Resets the 4155C/4156C.
110	Sets the mass storage device to the built-in flexible disk drive.
120	Loads a setup data file from a diskette.
130 to 150	Executes measurement and waits until completion.
170	This line is not used for this example. This line can be used to add a text to a header line. The :HCOP:ITEM subsystem commands can be used to add/select the output items.
180	Displays the GRAPH/LIST: LIST screen.
190	This line is not used for this example. This line can be used to return the items selected by the :HCOP:ITEM commands.
200	Returns the all of the print/plot output data.
220 to 280	Reads the print/plot output data, and saves it to a file.

To Save Hardcopy Image to a File

1. To set print/plot destination to a mass storage device, then specify the device, send the following commands:
   - :HCOP:DEST MMEM
   - :MMEM:DEST INT or :MMEM:DEST NET*n*

   where, *n* is 1, 2, 3 or 4.
2. Specify the file name by using :MMEMory:NAME command.
3. Execute the print/plot operation. Refer to print/plot tasks described previously.

Example

To load sweep setup file, execute measurement, and then saves a hardcopy image of the measurement results of GRAPH/LIST: GRAPHICS screen to a diskette:

```
10   ASSIGN @Hp415x TO 717
20   !
30   OUTPUT @Hp415x;"*RST"
40   !
50   OUTPUT @Hp415x;":MMEM:DEST INT"
60   OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'SWP.MES'"
70   !
80   OUTPUT @Hp415x;":PAGE:SCON:SING"
90   OUTPUT @Hp415x;"*OPC?"
100  ENTER @Hp415x;Complete
110  !
120  OUTPUT @Hp415x;":HCOP:DEST MMEM"
130  OUTPUT @Hp415x;":MMEM:NAME 'TEST1'"
140  !
150  OUTPUT @Hp415x;":PAGE:GLIS"
160  !
170  OUTPUT @Hp415x;":HCOP"
180  OUTPUT @Hp415x;"*OPC?"
190  ENTER @Hp415x;Complete
200  END
```

Line Number	Description
10	Assigns I/O path to control the 4155C/4156C.
30	Resets the 4155C/4156C.
50	Sets the mass storage device to the built-in flexible disk drive.
60	Loads measurement setup data from diskette file `SWP.MES`.
80 to 100	Executes measurement and waits until completion.
120	Specifies the destination to be diskette.
130	Specifies the diskette file name.
150	Displays GRAPH/LIST: GRAPHICS screen.
170 to 190	Starts printing and waits until completion.

Other Programming Tips

This section provides the advanced programming techniques and useful tips:

- Speed Improvement
- Auto-loading of Files
- Differences from 4155A/4156A/4155B/4156B SCPI Commands

Disabling Instrument Screen Update to Improve Speed

Most of the commands that control and set the 4155C/56C will also update the instrument screen.

For example, :PAGE:CHAN:MODE command changes the measurement mode. This command also changes the instrument screen to the CHANNELS: CHANNEL DEFINITION screen and updates the MEASUREMENT MODE field setting.

This instrument screen update is useful for confirming the settings that were changed by the commands, but it takes time. You can enable or disable this time consuming instrument screen update as follows:

:DISP OFF Instrument screen is not updated

:DISP ON Instrument screen is updated

where, :DISP OFF command is *NOT* available when the 4155C/4156C screen displays the following screen:

- SYSTEM: FILER
- SYSTEM: MISCELLANEOUS
- SYSTEM: CONFIGURATION
- SYSTEM: SELF-CALIBRATION/DIAGNOSTICS
- SYSTEM: PRINT/PLOT SETUP
- SYSTEM: COLOR SETUP
- KNOB SWEEP

Refer to *SCPI Command Reference*.

Auto-loading of Files

The the 4155C/56C can automatically load files when it is turned on.

INIT files for Initial Settings

If any setup files named `INIT.MES`, `INIT.STR`, `INIT.CST`, or `INIT.DAT` are on the diskette (in the built-in drive) when the 4155C/56C is turned on, the 4155C/56C automatically loads these setup files to be the initial settings.

This function saves you the trouble of getting application files every time you turn on the 4155C/56C.

NOTE

INIT.MES and INIT.DAT files

`INIT.MES` and `INIT.DAT` both contain measurement setup data. If both these files exist on the diskette, the 4155C/56C gets `INIT.DAT`, not `INIT.MES`.

MEM*no* Files

If any files named `MEM`*no*`.DAT`, `MEM`*no*`.MES`, or `MEM`*no*`.STR` are on the diskette in the drive, the files are automatically loaded from diskette to internal memory when the 4155C/56C is turned on. Where `MEM`*no* means `MEM1`, `MEM2`, `MEM3`, or `MEM4`, which correspond to the four internal memory areas.

If the same internal memory is specified by multiple files (for example, `MEM1.MES` and `MEM1.DAT`), the priority is as follows:

1. `DAT`
2. `MES`
3. `STR`

IBASIC Program File to Auto-execute

If an IBASIC program is stored in a file named "AUTOST" on the diskette in the built-in drive, the program is automatically loaded and started when you turn on the 4155C/56C.

Differences From 4155B/4156B SCPI Commands

The 4155C/4156C SCPI command set differs from the the 4155B/4156B SCPI command set in the following ways:

SCPI commands supported by the 4155C/4156C

The 4155C/4156C supports the following new commands:

- Quasi-static CV measurement:

  :PAGE:MEASure:QSCV subsystem commands

- E5250A control (available for the built-in IBASIC controller):

  :PAGE:CHANnels:MATrix subsystem commands

- Network capability:

SCPI Command	Description
:SYST:COMM:NET:SELF:SNET	Sets the subnet mask the 4155C/4156C connects to.
:SYST:COMM:NET:SELF:GATE	Sets the IP address of the gateway.

- System configuration query:

SCPI Command	Description
:SYST:CONF:ALL?	Returns all module information.
:SYST:CONF:SLOT?	Returns the specified module information.
:SYST:CONF:ETHE?	Returns the ethernet address.
:SYST:CONF:CREV?	Returns the CPU board revision.

- VMU discharge function:

  :PAGE:CHAN:CDEF:VMU<n>:DCH command

- Data display resolution:

  :PAGE:DISP:SET:DRESOL command

Differences in the Command Parameters

- :PAGE:CHAN:CDEF:MODE command

  Command parameters are different as shown below:

Model	Parameters available
4155A/4156A 4155B/4156B	SWEep, SAMPling
4155C/4156C	SWEep, SAMPling, QSCV

Differences From 4155A/4156A SCPI Commands

The 4155C/4156C SCPI command set differs from the the 4155A/4156A SCPI command set in the following ways:

For information on the built-in IBASIC controllor, refer to the “Differences from 4155A/4156A Programming” section in Chapter 1.

SCPI commands supported on 4155B/4156B/4155C/4156C

The following commands are *not* supported on the 4155A/4156A, but *are* supported on the 4155B/4156B/4155C/4156C:

- To enable/disable the screen saver:

  :SYST:SSAV command

- To select the mass storage memory:

  :MMEM:DEST command

- To setup the 4155/4156 network:

SCPI Command	Description
:SYST:COMM:NET:SELF:NAME	Sets the host name of the 4155/4156.
:SYST:COMM:NET:SELF:IPAD	Sets the IP address of the 4155/4156.
:SYST:COMM:NET:SELF:USER	Sets your user ID.
:SYST:COMM:NET:SELF:GROU	Sets your group ID.

- To use the 4155/4156 as a NFS client:

SCPI Command	Description
:SYST:COMM:NET:FILE:NET:NAME	Sets the label/name for the setup.
:SYST:COMM:NET:FILE:NET:IPAD	Sets the IP address of NFS server.
:SYST:COMM:NET:FILE:NET:DIR	Sets the default directory.
:SYST:COMM:NET:FILE:SET	Registers the NFS server setup.
:SYST:COMM:NET:FILE:DEL	Deletes the NFS server setup.
:MMEM:CDIR	Changes the working directory.

- To use a remote printer:

SCPI Command	Description
:SYST:COMM:NET:PRIN:NET:NAME	Sets the name of the remote printer.
:SYST:COMM:NET:PRIN:NET:IPAD	Sets the IP address of the print server.
:SYST:COMM:NET:PRIN:NET:TEXT	Sets the lpr text output option.
:SYST:COMM:NET:PRIN:NET:GRAP	Sets the lpr graphics output option.
:SYST:COMM:NET:PRIN:NET:TYPE	Specifies the server type.
:SYST:COMM:NET:PRIN:SET	Registers the remote printer setup.
:SYST:COMM:NET:PRIN:DEL	Deletes the remote printer setup.
:SYST:NTMO	Sets the print server timeout.

Differences in the Command Parameters

- :HCOP:DEST command

  The command parameters of the supported interfaces differ from the 4155A/4156A as follows, where NET*n*, *n* is 1, 2, 3, or 4.

Model	Serial	Parallel	GPIB	LAN	file
4155A/4156A	SERial		RDEVice		MMEMory
4155B/4156B 4155C/4156C		PARallel	RDEVice	NET*n*	MMEMory

- :HCOP:DEV:LANG command

  The print/plot function command parameters of the supported output formats differ as shown below. In the table, HR PCL means high resolution PCL, and HR TIFF means high resolution TIFF.

Model	PCL	HR PCL	HP-GL	TIFF	HR TIFF
4155A/4156A	PCL		HPGL		
4155B/4156B 4155C/4156C	PCL	HRPCl	HPGL	TIFF	HRTIff

Programming Example for 4145 Users

This section shows a programming example with SCPI commands that performs the same operations as the desired 4145 ASP program.

Built-in IBASIC can execute ASP-like commands for controlling the 4155C/4156C. Refer to “Creating ASP-like IBASIC Programs” in Chapter 5 on programming this commands.

Following program is the simplest example of creating an HP BASIC program (with SCPI commands) that performs the same operations as the desired 4145 ASP program. The ASP program gets a setup file named "VTH" from the diskette, makes a single measurement, then saves measurement to a file named "VT1".

```
                10 ASSIGN @Hp415x TO 800
                20 OUTPUT @Hp415x;":MMEM:DEST INT"
1 GET P   VTH   30 OUTPUT @Hp415x;":MMEM:LOAD:STAT 0,'VTH.PRO'"
2 SINGLE        40 OUTPUT @Hp415x;":PAGE:SCON:SING"
                50 OUTPUT @Hp415x;"*OPC?"
                60 ENTER @Hp415x;Complete
3 SAVE D  VT1   70 OUTPUT @Hp415x;":MMEM:STOR:TRAC DEF,'VT1.DAT'"
                80 END
```

The above HP BASIC program (with SCPI commands) does as follows:

- Line 10 assigns a path named `@Hp415x` to `800`, which is the select code/GPIB address to use if this is an IBASIC program running in the 4155C/56C. If this program will run on an external computer, use the select code of the GPIB interface and the GPIB address of the 4155C/4156C instead.
- Lines 20 to 30 get a measurement setup file named "VTH.MES". So, you need to save setup data to a file named "VTH.MES" on the diskette before executing this program. For an example setup, see “Example Application Setup for Vth Measurement” on page 2-26.
- Line 40 performs a single measurement.
- Line 70 saves measurement setup and result data to a file named `VTH1.DAT`.

For built-in help function, which makes it easier to enter the desired SCPI command, see “To Use the Help Function” in Chapter 1.

Following shows the 4145A/B's ASP keywords and corresponding SCPI commands of the 4155C/4156C:

Corresponding 4145 ASP and 4155C/56C SCPI Commands

4145A/B	SCPI Commands	Function
GET P	:MMEM:LOAD:STAT	Gets setup `.MES` or `.PRO` file
SINGLE	:PAGE:SCON:SING	Initiates single measurement
SAVE D	:MMEM:STOR:TRAC	Saves data to `.DAT` file
PLOT	:HCOP	Prints/plots present instrument screen.
CPLOT	:HCOP:ITEM:TRAC	Prints/plots measurement graph.
PRINT	:HCOP	Prints/plots present instrument screen.
PAUSE	(Use BASIC keyword PAUSE)	
WAIT	(Use BASIC keyword WAIT)	
PAGE	(Set in the Print/Plot setup)	

3 FLEX Command Programming

Agilent 4155C/4156C FLEX (Fast Language for EXecution) command set is designed to make automatic measurements via GPIB control. This is the fastest method of measurement for the 4155C/4156C.

This chapter describes how to create measurement programs, and provides program examples. It contains the following sections:

- “Programming Basics”
- “High-Speed Spot Measurements”
- “Spot Measurements”
- “1 Channel Pulsed Spot Measurements”
- “Staircase Sweep Measurements”
- “Pulsed Sweep Measurements”
- “Staircase Sweep with Pulsed Bias Measurements”
- “Sampling Measurements”
- “Quasi-static CV Measurements”
- “Linear Search Measurements”
- “Binary Search Measurements”
- “Stress Force”
- “Controlling PGU”
- “Using Program Memory”
- “Using Enhanced Sweep Stop Function”
- “Reading Time Stamp Data”
- “Reading and Writing Data to a File”
- “Printing Data”
- “Reading Binary Output Data”
- “Using the US42 Control Mode”
- “Programming Tips”

Refer to Chapter 1 of *GPIB Command Reference* for the command syntax and descriptions of the 4155C/4156C FLEX commands.

The following command conventions are used in this chapter.

command	Required command for measurement execution.
[command]	Optional command for measurement execution.
parameter	Required command parameter. A value or variable *must* be specified.
[*parameter*]	Optional command parameter. A value may be specified.

CAUTION

After the Automatic Measurement

After the automatic measurements, open the measurement terminals or disconnect the device under test from the measurement terminals. If you leave the connection with the device, the device may be damaged by unexpected operations.

Do not leave the connection over 30 minutes after the measurement if the auto calibration is set to ON. Then, the 4155C/4156C performs the self-calibration automatically every 30 minutes after the measurement. The calibration requires to open the measurement terminals.

To disable the auto calibration, enter the `CM 0` command.

Programming Basics

This section provides instructions for two methods of controlling and programming the 4155C/4156C.

- Controlling the 4155C/4156C via GPIB
- Controlling the 4155C/4156C using HP BASIC

Controlling 4155C/4156C via GPIB

To control the 4155C/4156C via GPIB, you can use an external computer or the built-in Instrument BASIC (IBASIC) controller.

NOTE

Device Clear

The 4155C/4156C requires approximately 2 seconds for the GPIB device clear. For HP BASIC or IBASIC, enter the CLEAR command.

Controlling from an External Computer

To control the 4155C/4156C using an external computer:

1. Connect the GPIB interface of the external computer to the GPIB connector on the rear panel of the 4155C/4156C.
2. Set the "`4155C/56C is`" field on the SYSTEM: MISCELLANEOUS screen to NOT SYSTEM CONTROLLER.
3. Enter the GPIB address of the 4155C/4156C in the "`GPIB ADDRESS`" field.

Controlling from a built-in IBASIC controller

If you use a built-in IBASIC controller, no preparation is required. The built-in IBASIC controller is always connected to the 4155C/4156C via internal GPIB.

To control external instruments:

1. Connect the GPIB interface for the external instruments to the GPIB connector on the rear panel of the 4155C/4156C.
2. Set the "`4155C/56C is`" field on the SYSTEM: MISCELLANEOUS screen to SYSTEM CONTROLLER.

To use the remote printer connected to the print server:

1. Connect the 4155C/4156C to your LAN.
2. Set the "`4155C/56C NETWORK SETUP`" table, "`NETWORK PRINTER SETUP`" table, and "`NETWORK DRIVE SETUP`" table on the SYSTEM: MISCELLANEOUS screen.

To use the network file system on the NFS server:

1. Connect the 4155C/4156C to your LAN.
2. Set the "`4155C/56C NETWORK SETUP`" table and "`NETWORK DRIVE SETUP`" table on the SYSTEM: MISCELLANEOUS screen.

Controlling 4155C/4156C Using HP BASIC Programming

1. To assign the I/O path for controlling the 4155C/4156C, use the ASSIGN command.
   - Built-in IBASIC

     Specify select code 8. For the GPIB address, you can use *any* number from 0 to 31. Refer to the following example.

     ```
     10 ASSIGN @Hp415x TO 800
     ```
   - HP BASIC on an external computer

     Specify the select code of the external computer and specify the GPIB address that you entered in the "`GPIB ADDRESS`" field on the SYSTEM: MISCELLANEOUS screen.

     In the following example, the select code of the external computer is 7 and the GPIB address of the 4155C/4156C is 17.

     ```
     10 ASSIGN @Hp415x TO 717
     ```
2. To send commands to the 4155C/4156C, use the OUTPUT command, as shown in the following example.

   ```
   OUTPUT @Hp415x;"US"
   ```

   The 4155C/4156C will only accept a single statement in an OUTPUT command. Do *not* enter multiple statements.
3. To get a query response or output data from the 4155C/4156C, use the ENTER command.

High-Speed Spot Measurements

To make high-speed spot measurements, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets Filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets Averaging Number	[AV]	*number*[,*mode*]
Sets Integration Time	[SIT]	*type*,*time*
	[SLI]	*type*
Forces constant voltage	DV	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	DI	*chnum*,*range*,*output*[,*Vcomp*]
Measures current	TI	*chnum*,*range*
Measures voltage	TV	*chnum*,*range*
Reads measurement data (for TI/TV command)	RMD?	*number_of_data*
Measures current and reads data	TI?	*chnum*,*range*
Measures voltage and reads data	TV?	*chnum*,*range*

You can use the DV/DI commands, and TI/TV *or* TI?/TV? commands regardless of the measurement mode (MM command settings).

You *cannot* use both the TI/TV commands and the TI?/TV? commands in the same measurement program.

A program example of a high-speed spot measurement is shown below. This program executes the current measurement, using the TI? command, and prints the measured data on the screen.

```
10    ASSIGN @Hp415x TO 800
20   !
30    INTEGER Fmt,Average,Type,Source,Drain,Gate,Sub
40    INTEGER Range_2v,Range_20v,Range_i,B,C
50    DIM B$[50]
60   !
70    Fmt=1            !1:ASCII with Header <LF^EOI>
80    Average=1        !Number of averaging
90    Sinteg=.0005     !Integ Time of Short
100   Linteg=.04       !Integ Time of Long
110   Type=1           !1:Short, 2:Medium, 3:Long
120   Filter=0         !0:Filter off, 1:Filter on
130   Source=1         !1:SMU1
140   Drain=2          !2:SMU2
150   Gate=3           !3:SMU3
160   Sub=4            !4:SMU4
170   Range_2v=11      !11: 2 V Limited Auto Ranging
180   Range_20v=12     !12:20 V Limited Auto Ranging
190   Range_i=15       !15:10 uA Limited Auto Ranging
200   Vs=0             ! Source Voltage
210   Vd=5             ! Drain Voltage
220   Vg=3             ! Gate Voltage
230   Vsub=0           ! Substrate Voltage
240   Icomp_g=.01      ! Current compliance for gate
250   Icomp=.1         ! Current compliance
260  !
270   OUTPUT @Hp415x;"US"
280   OUTPUT @Hp415x;"FMT ";Fmt
290   OUTPUT @Hp415x;"AV ";Average
300   OUTPUT @Hp415x;"SIT 1,";Sinteg   !for Short
310   OUTPUT @Hp415x;"SIT 3,";Linteg   !for Long
320   OUTPUT @Hp415x;"SLI ";Type
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
70 to 250	Sets the measurement parameters.
270	Enters the 4155C/4156C FLEX command control mode.
280	Specifies the data output format.
290 to 320	Sets the integration time.

```
330   OUTPUT @Hp415x;"FL ";Filter
340   OUTPUT @Hp415x;"CN ";Source,Drain,Gate,Sub
350   OUTPUT @Hp415x;"DV ";Source,Range_2v,Vs,Icomp
360   OUTPUT @Hp415x;"DV ";Sub,Range_2v,Vsub,Icomp
370   OUTPUT @Hp415x;"DV ";Gate,Range_20v,Vg,Icomp_g
380   OUTPUT @Hp415x;"DV ";Drain,Range_20v,Vd,Icomp
390  !
400   OUTPUT @Hp415x;"*OPC?"
410   ENTER @Hp415x;C
420  !
430   OUTPUT @Hp415x;":SYST:ERR?"
440   ENTER @Hp415x;B,B$
450   IF B=0 THEN
460     OUTPUT @Hp415x;"TI? ";Drain,Range_i
470     ENTER @Hp415x USING "#,5X,13D,X";A
480     PRINT "Id(A)=";A
490   ELSE
500     PRINT "ERROR:";B$
510   END IF
520  !
530   OUTPUT @Hp415x;"CL"
540   OUTPUT @Hp415x;":PAGE"
550   END
```

Line Number	Description
330	Sets the filter mode.
340	Enables the measurement units.
350 to 380	Forces the dc voltage.
400 to 410	Waits for the operation complete flag.
430 to 440	Checks for errors.
460 to 480	Executes a high-speed spot measurement and prints the results on the screen.
500	Displays an error code if an error has occurred.
530	Disables the measurement units.
540	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Spot Measurements

To make spot measurements, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets Filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets Averaging Number	[AV]	*number*[,*mode*]
Sets Integration Time	[SIT]	*type*,*time*
	[SLI]	*type*
Forces constant voltage	DV	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	DI	*chnum*,*range*,*output*[,*Vcomp*]
Sets VMU measurement mode	[VM]	*chnum*,*mode*
Sets voltage measurement range	[RV]	*chnum*,*range*[,*Rmode*]
Sets current measurement range	[RI]	*chnum*,*range*[,*Rmode*]
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	1,*chnum*[,*chnum* ... [,*chnum*] ...]
Sets SMU measurement mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

A program example of a spot measurement is shown below. This program executes the current measurement and prints the measured data on the screen.

```
10    ASSIGN @Hp415x TO 800
20   !
30    INTEGER Fmt,Average,Type,Source,Drain,Gate,Sub
40    INTEGER Range_2v,Range_20v,Range_i,B,C
50    DIM B$[50]
60   !
70    Fmt=1            !1:ASCII with Header <LF^EOI>
80    Average=1        !Number of averaging
90    Sinteg=.0005     !Integ Time of Short
100   Linteg=.04       !Integ Time of Long
110   Type=1           !1:Short, 2:Medium, 3:Long
120   Filter=0         !0:Filter off, 1:Filter on
130   Source=1         !1:SMU1
140   Drain=2          !2:SMU2
150   Gate=3           !3:SMU3
160   Sub=4            !4:SMU4
170   Range_2v=11      !11: 2 V Limited Auto Ranging
180   Range_20v=12     !12:20 V Limited Auto Ranging
190   Range_i=15       !15:10 uA Limited Auto Ranging
200   Vs=0             ! Source Voltage
210   Vd=5             ! Drain Voltage
220   Vg=3             ! Gate Voltage
230   Vsub=0           ! Substrate Voltage
240   Icomp_g=.01      ! Current compliance for gate
250   Icomp=.1         ! Current compliance
260   Mmode=1          !1:Spot Measurement
270   Smode=1          !1:Current Measurement
280   Mnum=1           !Number of measurement data
290  !
300   OUTPUT @Hp415x;"US"
310   OUTPUT @Hp415x;"FMT ";Fmt
320   OUTPUT @Hp415x;"AV ";Average
330   OUTPUT @Hp415x;"SIT 1,";Sinteg   !for Short
340   OUTPUT @Hp415x;"SIT 3,";Linteg   !for Long
350   OUTPUT @Hp415x;"SLI ";Type
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
70 to 280	Sets the measurement parameters.
300	Enters the 4155C/4156C FLEX command control mode.
310	Specifies the data output format.
320 to 350	Sets the integration time.

```
360   OUTPUT @Hp415x;"FL ";Filter
370   OUTPUT @Hp415x;"CN ";Source,Drain,Gate,Sub
380   OUTPUT @Hp415x;"DV ";Source,Range_2v,Vs,Icomp
390   OUTPUT @Hp415x;"DV ";Sub,Range_2v,Vsub,Icomp
400   OUTPUT @Hp415x;"DV ";Gate,Range_20v,Vg,Icomp_g
410   OUTPUT @Hp415x;"DV ";Drain,Range_20v,Vd,Icomp
420   OUTPUT @Hp415x;"MM ";Mmode,Drain
430   OUTPUT @Hp415x;"CMM ";Drain,Smode
440   OUTPUT @Hp415x;"XE"
450  !
460   OUTPUT @Hp415x;":SYST:ERR?"
470   ENTER @Hp415x;B,B$
480   OUTPUT @Hp415x;"CL"
490   IF B=0 THEN
500     OUTPUT @Hp415x;"RMD? ";Mnum
510     ENTER @Hp415x USING "#,5X,13D,X";A
520     PRINT "Id(A)=";A
530   ELSE
540     PRINT "ERROR:";B$
550   END IF
560  !
570   OUTPUT @Hp415x;":PAGE"
580   END
```

Line Number	Description
360	Sets the filter mode.
370	Enables the measurement units.
380 to 410	Forces the dc voltage.
420	Sets the measurement mode.
430	Sets the SMU measurement mode.
440	Executes a spot measurement.
460 to 470	Checks for errors.
480	Disables the measurement units.
500 to 520	Reads the measurement data and prints the results on the screen.
540	Displays an error code if an error has occurred.
570	Returns to the 4155C/4156C default control mode (SCPI command control mode).

1 Channel Pulsed Spot Measurements

To make 1 channel pulsed spot measurements, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets Filter ON/OFF	[FL] [a]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets Averaging Number	[AV] [b]	*number*[,*mode*]
Sets Integration Time	[SIT]	*type*,*time*
	[SLI] [b]	*type*
Forces constant voltage	[DV]	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	[DI]	*chnum*,*range*,*output*[,*Vcomp*]
Sets pulse source timing parameters	PT	*hold*,*width*[,*period* [,*trigger_delay*[,*priority*]]]
Forces pulse voltage	PV	*chnum*,*range*,*base*,*pulse*[,*Icomp*]
Forces pulse current	PI	*chnum*,*range*,*base*,*pulse* [,*Vcomp*]
Sets voltage measurement range	[RV]	*chnum*,*range*[,*Rmode*]
Sets current measurement range	[RI]	*chnum*,*range*[,*Rmode*]
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	3,*chnum*[,*chnum* ... [,*chnum*] ..] [c]
Sets SMU measurement mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

a. For the pulse source, the filter must be set to OFF.
b. If the PT command *priority* parameter specifies the "keep pulse width" mode, the AV and SLI commands are ignored. The integration time is automatically set to 80 µsec.
c. If the PT command *priority* parameter specifies the "keep pulse width" mode, the available number of *chnum*s is 1.

A program example of a 1 channel pulsed spot measurement is shown below. This program executes the current measurement and prints the measured data on the screen.

```
10      ASSIGN @Hp415x TO 800
20     !
30      INTEGER Emitter,Base,Collector,Mmode,Fmt,Filter
40      INTEGER Range,Mnum,B
50      REAL Vcomp,Icomp,Ve,Ibbase,Ibpulse,Ic,Hold,Width
60      DIM B$[50]
70     !
80      Emitter=1       ! 1: SMU1
90      Base=2          ! 2: SMU2
100     Collector=3     ! 3: SMU3
110     Fmt=1           ! 1:ASCII with Header <LF^EOI>
120     Filter=0        ! Filter mode. 0: OFF, 1: ON
130     Range=0         ! Auto ranging
140     Vcomp=2         ! V compliance (V) for base/collector
150     Icomp=.1        ! I compliance (A) for emitter
160     Ve=0            ! Emitter voltage (V)
170     Ibbase=0        ! Base current base value (A)
180     Ibpulse=.005    ! Base current pulse value (A)
190     Ic=.05          ! Collector current (A)
200     Hold=0          ! Hold time (sec) of Ib
210     Width=.001      ! Pulse width (sec) of Ib
220     Mnum=1          ! Number of measurement points
230     Mmode=3         ! 3: 1CH pulsed spot measurement
240    !
250     OUTPUT @Hp415x;"US"
260     OUTPUT @Hp415x;"FMT ";Fmt
270     OUTPUT @Hp415x;"CN ";Emitter,Base,Collector
280     OUTPUT @Hp415x;"FL ";Filter,Base
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
80 to 230	Sets the measurement parameters.
250	Enters the 4155C/4156C FLEX command control mode.
260	Specifies the data output format.
270	Enables the measurement units.
280	Sets the filter mode.

```
290    OUTPUT @Hp415x;"PT ";Hold,Width
300    OUTPUT @Hp415x;"PI ";Base,Range,Ibbase,Ibpulse,Vcomp
310    OUTPUT @Hp415x;"DV ";Emitter,Range,Ve,Icomp
320    OUTPUT @Hp415x;"DI ";Collector,Range,Ic,Vcomp
330    OUTPUT @Hp415x;"MM ";Mmode,Collector
340    OUTPUT @Hp415x;"XE"
350   !
360    OUTPUT @Hp415x;":SYST:ERR?"
370    ENTER @Hp415x;B,B$
380    OUTPUT @Hp415x;"CL"
390    IF B=0 THEN
400      GOTO 460
410    ELSE
420      PRINT B,B$
430      GOTO 500
440    END IF
450   !
460    OUTPUT @Hp415x;"RMD? ";Mnum
470    ENTER @Hp415x USING "#,5X,13D,X";Mdata
480    PRINT "Vce(V)= ";Mdata
490   !
500    OUTPUT @Hp415x;":PAGE"
510    END
```

Line Number	Description
290 to 300	Sets the pulse current source (base current).
310	Forces the dc voltage (Ve).
320	Forces the dc current (Ic).
330	Sets the measurement mode.
340	Executes a 1ch pulsed spot measurement.
360 to 370	Checks for errors.
380	Disables the measurement units.
460 to 480	Reads the measurement data and prints the results on the screen.
500	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Staircase Sweep Measurements

To make staircase sweep measurements, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets Filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets Averaging Number	[AV]	*number*[,*mode*]
Sets Integration Time	[SIT]	*type*,*time*
	[SLI]	*type*
Sets sweep source timing parameter	[WT]	*hold*,*delay*[,*step delay*]
Sets staircase sweep source	WV	*ch*,*mode*,*range*,*start*,*stop*,*step* [,*Icomp*[,*Pcomp*[,*Rmode*]]]
	WI	*ch*,*mode*,*range*,*start*,*stop*,*step* [,*Vcomp*[,*Pcomp*[,*Rmode*]]]
Sets sweep abort function	[WM]	*abort*[,*post*]
Sets synchronous sweep source [a]	[WSV]	*ch*,*range*,*start*,*stop*[,*Icomp* [,*Pcomp*[,*Rmode*]]]
	[WSI]	*ch*,*range*,*start*,*stop*[,*Vcomp* [,*Pcomp*[,*Rmode*]]]
Forces constant voltage	[DV]	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	[DI]	*chnum*,*range*,*output*[,*Vcomp*]
Sets VMU measurement mode	[VM]	*chnum*,*mode*
Sets voltage measurement range	[RV]	*chnum*,*range*[,*Rmode*]

Function	FLEX Command	Parameters
Sets current measurement range	[RI]	*chnum*,*range*[,*Rmode*]
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	2,*chnum*[,*chnum* ... [,*chnum*] ...]
Sets SMU measurement mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

a. The WSV/WSI command must be entered after the WV/WI command.

A program example of a staircase sweep measurement is shown below. This program executes the bipolar transistor Ic-Vc characteristics measurement and prints the measured data list on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Te,Tb,Tc,Irange,Range,Var1,Var2
40      DIM St$[3],Ch$[1],Md$[1],C$[100]
50     !
60      Te=1            ! 1: SMU1
70      Tb=2            ! 2: SMU2
80      Tc=3            ! 3: SMU3
90      Var1=11         ! Collector voltage number of steps
100     Var2=3          ! Number of Ib steps
110     Vc1=0           ! Collector voltage start value (V)
120     Vc2=1           ! Collector voltage stop value (V)
130     Ic_comp=.003    ! Current compliance (A) for collector
140     Ve=0            ! Emitter voltage (V)
150     Ie_comp=.1      ! Current compliance (A) for emitter
160     Ib1=1.E-5       ! Ib start value (A)
170     Ib2=3.E-5       ! Ib stop value (A)
180     Vb_comp=2       ! Voltage compliance (V) for base
190     Irange=14       ! 14: 1 uA limited auto ranging
200     Range=0         ! 0: Auto ranging
210    !
220     OUTPUT @Hp415x;"US"
230     OUTPUT @Hp415x;"FMT 1,1"     !Data w/Header,Source data
240     OUTPUT @Hp415x;"CN ";Te,Tb,Tc
250     OUTPUT @Hp415x;"MM 2,";Tc    !Sweep measurement
260     OUTPUT @Hp415x;"WM 2,1"      !Stops any abnormal
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
60 to 200	Sets the measurement parameters.
220	Enters the 4155C/4156C FLEX command control mode.
230	Specifies the data output format.
240	Enables the measurement units.
250	Sets the staircase sweep measurement mode.
260	Enables measurement abort function for abnormal conditions.

```
270    OUTPUT @Hp415x;"WV ";Tc,1,Range,Vc1,Vc2,Var1,Ic_comp
280    OUTPUT @Hp415x;"RI ";Tc,Irange
290    OUTPUT @Hp415x;"DV ";Te,Range,Ve,Ie_comp
300   !
310    FOR I=1 TO Var2
320      Ib=Ib1+(I-1)*(Ib2-Ib1)/(Var2-1)
330      OUTPUT @Hp415x;"DI ";Tb,Range,Ib,Vb_comp
340      OUTPUT @Hp415x;"XE"
350      OUTPUT @Hp415x;"*OPC?"
360      ENTER @Hp415x;C
370      OUTPUT @Hp415x;":SYST:ERR?"
380      ENTER @Hp415x;C,C$
390      IF C<>0 THEN
400        PRINT "ERROR:";C,C$
410        BEEP
420        DISP "Press Continue to read data. Or press Stop."
430        PAUSE
440        DISP ""
450      END IF
460     !
```

Line Number	Description
270	Sets the staircase sweep source (Vc).
280	Sets the measurement range (Ic).
290	Forces the dc voltage (Ve).
320	Calculates the base current value.
330	Forces the dc current (Ib).
340 to 360	Executes a staircase sweep measurement.
370 to 450	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.

```
470   ! Reading data
480      OUTPUT @Hp415x;"NUB?"
490      ENTER @Hp415x;C
500      IF C<>0 THEN
510        PRINT "Ib=";Ib*1.E+6;"(uA)"
520        FOR N=1 TO C
530          OUTPUT @Hp415x;"RMD? 1"
540         ENTER @Hp415x USING "#,3A,A,A,13D,X";St$,Ch$,Md$,Mdata
550          IF Md$="I" THEN
560            PRINT " Ic=";Mdata*1000;"(mA), Status=";St$
570          ELSE
580            IF Md$="v" THEN
590              PRINT " Vc=";Mdata*1000;"(mV), Status=";St$
600            ELSE
610              PRINT " XX=INVALID DATA, Status=";St$
620            END IF
630          END IF
640        NEXT N
650      ELSE
660        PRINT "STATUS: No data returned."
670      END IF
680    NEXT I
690    OUTPUT @Hp415x;"CL"
700    OUTPUT @Hp415x;":PAGE"
710    END
```

Line Number	Description
480 to 490	Confirms the number of data stored in the output buffer.
530 to 540	Reads the measurement data.
550 to 590	Displays the measurement data, Ic and Vc.
610	Displays “XX=INVALID DATA” if the data is not the current measurement data or the voltage output data.
660	Displays “No data returned” if the number of data is zero.
690	Disables the measurement units.
700	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

The following program example executes the synchronous sweep measurement using two sweep sources. This program executes the MOS FET Id-Vg characteristics measurement and prints the measured data list on the screen.

```
10      ASSIGN @Hp415x TO 800
20      INTEGER Source,Drain,Gate,Sub,Range_v,Range_i
30      DIM A$[100]
40    !
50      Drain=1         !1:SMU1
60      Gate=2          !2:SMU2
70      Sub=3           !3:SMU3
80      Source=4        !4:SMU4
90      Range_v=0       !0: Auto Ranging
100     Range_i=15      !15:10 uA Limited Auto Ranging
110     Vs=0            ! Source Voltage
120     Vd=3            ! Drain Voltage
130     Vg=3            ! Gate Voltage
140     Vsub=0          ! Substrate Voltage
150     Icomp_g=.01     ! Current compliance for gate
160     Icomp=.011      ! Current compliance
170     Var1=11         ! Number of Var1 step
180   !
190     OUTPUT @Hp415x;"US"
200     OUTPUT @Hp415x;"FMT 1,0"      !Data w/Header, No Source_data
210     OUTPUT @Hp415x;"MM 2,";Drain !Sweep measurement
220     OUTPUT @Hp415x;"WM 2,1"       !Stops any abnormal
230     OUTPUT @Hp415x;"CN ";Source,Drain,Gate,Sub
240     OUTPUT @Hp415x;"DV ";Source,Range_v,Vs,Icomp
250     OUTPUT @Hp415x;"DV ";Sub,Range_v,Vsub,Icomp
260     OUTPUT @Hp415x;"WV ";Drain,1,Range_v,0,Vd,Var1,Icomp
270     OUTPUT @Hp415x;"WSV ";Gate,Range_v,0,Vg,Icomp_g
280     OUTPUT @Hp415x;"RI ";Drain,Range_i
290    !
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
50 to 170	Sets the measurement parameters.
190	Enters the 4155C/4156C FLEX command control mode.
200	Specifies the data output format.
210	Sets the staircase sweep measurement mode.
220	Enables measurement abort function for abnormal conditions.
230	Enables the measurement units.
240 to 270	Forces the dc voltage, and sets the voltage sweep sources.
280	Sets the current measurment range.

```
300    OUTPUT @Hp415x;"XE"
310    OUTPUT @Hp415x;"*OPC?"
320    ENTER @Hp415x;A
330    OUTPUT @Hp415x;":SYST:ERR?"
340    ENTER @Hp415x;A,A$
350    IF A<>0 THEN
360      PRINT "ERROR:";A,A$
370      BEEP
380      DISP "Press press Continue to read data. Or press Stop."
390      PAUSE
400      DISP ""
410    END IF
420   !
430   ! Reading data
440    OUTPUT @Hp415x;"NUB?"
450    ENTER @Hp415x;A
460    IF A<>0 THEN
470      FOR I=1 TO A
480        OUTPUT @Hp415x;"RMD? 1"
490        ENTER @Hp415x USING "#,3A,X,A,13D,X";A$,B$,Mdata
500        IF B$="I" THEN
510          PRINT "Id=";Mdata*1000;"(mA), Status=";A$
520        ELSE
530          PRINT "XX=INVALID DATA, Status=";A$
540        END IF
550      NEXT I
560    ELSE
570      PRINT "STATUS: No data returned."
580    END IF
590    OUTPUT @Hp415x;"CL"
600    OUTPUT @Hp415x;":PAGE"
610    END
```

Line Number	Description
300 to 320	Executes the sweep measurement.
330 to 410	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.
440 to 450	Confirms the number of data stored in the output buffer.
480 to 510	Reads the measurement data, and displays the measurement data.
530	Displays “XX=INVALID DATA” if the data is not the current measurement data.
570	Displays “No data returned” if the number of data is zero.
590	Disables the measurement units.
600	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

Pulsed Sweep Measurements

To make staircase sweep measurements, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets Filter ON/OFF	[FL] [a]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets Averaging Number	[AV] [b]	*number*[,*mode*]
Sets Integration Time	[SIT]	*type*,*time*
	[SLI] [b]	*type*
Sets pulse source timing parameters	PT	*hold*,*width*[,*period* [,*trigger_delay* [,*priority*]]]
Sets pulsed sweep source	PWV	*ch*,*mode*,*range*,*base*,*start*,*stop*, *step*[,*Icomp*[,*Rmode*]]
	PWI	*ch*,*mode*,*range*,*base*,*start*,*stop*, *step*[,*Vcomp*[,*Rmode*]]
Sets sweep abort function	[WM]	*abort*[,*post*]
Sets synchronous sweep source [c]	[WSV]	*ch*,*range*,*start*,*stop*[,*Icomp* [,*Pcomp*[,*Rmode*]]]
	[WSI]	*ch*,*range*,*start*,*stop*[,*Vcomp* [,*Pcomp*[,*Rmode*]]]
Forces constant voltage	[DV]	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	[DI]	*chnum*,*range*,*output*[,*Vcomp*]
Sets voltage measurement range	[RV]	*chnum*,*range*[,*Rmode*]

Function	FLEX Command	Parameters
Sets current measurement range	[RI]	*chnum*,*range*[,*Rmode*]
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	4,*chnum*[,*chnum* ... [,*chnum*] ..] [d]
Sets SMU measurement mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

a. For the pulse source, the filter must be set to OFF.
b. If the PT command *priority* parameter specifies the "keep pulse width" mode, the AV and SLI commands are ignored. The integration time is automatically set to 80 µsec.
c. The WSV/WSI command must be entered after the PWV/PWI command.
d. If the PT command *priority* parameter specifies the "keep pulse width" mode, the available number of *chnum*s is 1.

A program example of a pulsed sweep measurement is shown below. This program executes the bipolar transistor Ib-Vb and Ic-Vb characteristics measurement and prints the measured data list on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Emitter,Base,Collector,Pri,Linlog,Mrange,Range
40      DIM A$[100],Channel$(4)[1]
50      Channel$(1)="A"
60      Channel$(2)="B"
70      Channel$(3)="C"
80      Channel$(4)="D"
90     !
100     Emitter=1       ! 1: SMU1
110     Base=2          ! 2: SMU2
120     Collector=3     ! 3: SMU3
130     Hold=1          ! Hold time
140     Width=.001      ! Pulse width
150     Period=.01      ! Pulse period
160     Delay=0         ! Trigger delay
170     Pri=1           ! 1: Wait meas. 0: Keep pulse width.
180     Linlog=1        ! 1: Linear single sweep mode
190     V0=0            ! Base pulse voltage base value (V)
200     V1=0            ! Base pulse voltage start value (V)
210     V2=1            ! Base pulse voltage stop value (V)
220     Comp=.002       ! Current compliance (A) of base
230     Ve=0            ! Emitter voltage (V)
240     Vc=1            ! Collector voltage (V)
250    Icomp=.1        ! Current compliance (A) of emitter/collector
260     Mrange=11       ! 11: 1 nA limited auto ranging
270     Range=0         ! 0: Auto ranging
280     Var1=11         ! Number of Var1 step
290    !
300     OUTPUT @Hp415x;"US"
310     OUTPUT @Hp415x;"FMT 1,1"      !Data w/Header,Source_data
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
100 to 280	Sets the measurement parameters.
300	Enters the 4155C/4156C FLEX command control mode.
310	Specifies the data output format.

```
320    OUTPUT @Hp415x;"FL 0,";Base   !Filter off
330    OUTPUT @Hp415x;"CN ";Emitter,Base,Collector
340    OUTPUT @Hp415x;"PT ";Hold,Width,Period,Delay,Pri
350    OUTPUT @Hp415x;"MM 4,";Base,Collector !Pulsed sweep
360    OUTPUT @Hp415x;"WM 2,1"               !Stops any abnormal
370    OUTPUT @Hp415x;"PWV ";Base,Linlog,Range,V0,V1,V2,Var1,Comp
380    OUTPUT @Hp415x;"DV ";Emitter,Range,Ve,Icomp
390    OUTPUT @Hp415x;"DV ";Collector,Range,Vc,Icomp
400    OUTPUT @Hp415x;"RI ";Base,Mrange
410    OUTPUT @Hp415x;"RI ";Collector,Mrange
420   !
430    OUTPUT @Hp415x;"XE"
440    OUTPUT @Hp415x;"*OPC?"
450    ENTER @Hp415x;A
460    OUTPUT @Hp415x;"CL"
470    OUTPUT @Hp415x;":SYST:ERR?"
480    ENTER @Hp415x;A,A$
490    IF A<>0 THEN
500      PRINT "ERROR:";A,A$
510      BEEP
520      DISP "Press press Continue to read data. Or press Stop."
530      PAUSE
540      DISP ""
550    END IF
560   !
```

Line Number	Description
320	Sets the filter mode.
330	Enables the measurement units.
340	Sets the pulse timing parameters.
350	Sets the pulsed sweep measurement mode.
360 to 370	Sets the sweep stop function, and sets the pulsed sweep source.
380 to 390	Forces the dc voltage.
400 to 410	Sets the measurement range.
430 to 450	Executes a pulsed sweep measurement.
460	Disables the measurement units.
470 to 550	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.

```
570   ! Reading data
580    OUTPUT @Hp415x;"NUB?"
590    ENTER @Hp415x;C
600    IF C<>0 THEN
610      FOR I=1 TO C
620        OUTPUT @Hp415x;"RMD? 1"
630        ENTER @Hp415x USING "#,3A,A,A,13D,X";St$,Ch$,Md$,Mdata
640        IF Md$="v" THEN
650          PRINT " Vb=";Mdata*1000;"(mV), Status=";St$
660        ELSE
670          IF Md$="I" THEN
680            IF Ch$=Channel$(Base) THEN
690              PRINT "INDEX=";INT((I+2)/3)
700              PRINT " Ib=";Mdata*1000;"(mA), Status=";St$
710            ELSE
720              IF Ch$=Channel$(Collector) THEN
730                PRINT " Ic=";Mdata*1000;"(mA), Status=";St$
740              ELSE
750                PRINT " XX=INVALID DATA, Status=";St$
760              END IF
770            END IF
780          ELSE
790            PRINT " XX=INVALID DATA, Status=";St$
800          END IF
810        END IF
820      NEXT I
830    ELSE
840      PRINT "STATUS: No data returned."
850    END IF
860    OUTPUT @Hp415x;":PAGE"
870    END
```

Line Number	Description
580 to 590	Confirms the number of data stored in the output buffer.
620 to 740	Reads the measurement data, and displays the measurement data.
750 to 790	Displays “XX=INVALID DATA” if the data is not the current measurement data or the voltage output data.
840	Displays “No data returned” if the number of data is zero.
860	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

Staircase Sweep with Pulsed Bias Measurements

To make staircase sweep with pulsed bias measurements, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets Filter ON/OFF	[FL] [a]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets Averaging Number	[AV] [b]	*number*[,*mode*]
Sets Integration Time	[SIT]	*type*,*time*
	[SLI] [b]	*type*
Sets pulse source timing parameters	PT	*hold*,*width*[,*period* [,*trigger_delay*[,*priority*]]]
Forces pulse voltage	PV	*chnum*,*range*,*base*,*pulse*[,*Icomp*]
Forces pulse current	PI	*chnum*,*range*,*base*,*pulse* [,*Vcomp*]
Sets staircase sweep source	WV	*ch*,*mode*,*range*,*start*,*stop*,*step* [,*Icomp*[,*Pcomp*[,*Rmode*]]]
	WI	*ch*,*mode*,*range*,*start*,*stop*,*step* [,*Vcomp*[,*Pcomp*[,*Rmode*]]]
Sets sweep abort function	[WM]	*abort*[,*post*]
Forces constant voltage	[DV]	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	[DI]	*chnum*,*range*,*output*[,*Vcomp*]
Sets voltage measurement range	[RV]	*chnum*,*range*[,*Rmode*]

Function	FLEX Command	Parameters
Sets current measurement range	[RI]	*chnum*,*range*[,*Rmode*]
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	5,*chnum*[,*chnum* ... [,*chnum*] ..] [c]
Sets SMU measurement mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

a. For the pulse source, the filter must be set to OFF.
b. If the PT command *priority* parameter specifies the "keep pulse width" mode, the AV and SLI commands are ignored. The integration time is automatically set to 80 µsec.
c. If the PT command *priority* parameter specifies the "keep pulse width" mode, the available number of *chnum*s is 1.

A program example of a staircase sweep with pulsed bias measurement is shown below. This program executes the bipolar transistor Ic-Vc characteristics measurement and prints the measured data list on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Emitter,Base,Col,Pri,Linlog,Mrange,Range
40      DIM C$[100]
50     !
60      Emitter=1       ! 1: SMU1
70      Base=2          ! 2: SMU2
80      Col=3           ! 3: SMU3
90      Hold=1          ! Hold time
100     Width=.001      ! Pulse width
110     Period=.01      ! Pulse period
120     Delay=0         ! Trigger delay
130     Pri=0           ! 1: Wait meas. 0: Keep pulse width.
140     Linlog=1        ! 1: Linear single sweep mode
150     Vc1=0           ! Collector voltage start value (V)
160     Vc2=1           ! Collector voltage stop value (V)
170     Comp=.1         ! Current compliance (A) for collector
180     Ve=0            ! Emitter voltage (V)
190     Ie_comp=.003    ! Current compliance (A) for emitter
200     Ib_base=0       ! Ib pulse base value (A)
210     Ib1=1.E-5       ! Ib start value (A)
220     Ib2=1.E-5       ! Ib step value (A)
230     Vb_comp=1       ! Voltage compliance (V) for base
240     Mrange=14       ! 14: 1 uA limited auto ranging
250     Range=0         ! 0: Auto ranging
260     Var1=11         ! Number of Var1 step
270     Var2=3          ! Number of Var2 step
280    !
290     OUTPUT @Hp415x;"US"
300     OUTPUT @Hp415x;"FMT 1,1"      !Data w/Header,Source_data
310     OUTPUT @Hp415x;"FL 0,";Base   !Filter off
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
60 to 270	Sets the measurement parameters.
290	Enters the 4155C/4156C FLEX command control mode.
300	Specifies the data output format.
310	Sets the filter mode.

```
320    OUTPUT @Hp415x;"CN ";Emitter,Base,Col
330    OUTPUT @Hp415x;"PT ";Hold,Width,Period,Delay,Pri
340    OUTPUT @Hp415x;"MM 5,";Col !Sweep with pulsed bias
350    OUTPUT @Hp415x;"WM 2,1"          !Stops any abnormal
360    OUTPUT @Hp415x;"WV ";Col,Linlog,Range,Vc1,Vc2,Var1,Comp
370    OUTPUT @Hp415x;"RI ";Col,Mrange
380    OUTPUT @Hp415x;"DV ";Emitter,Range,Ve,Ie_comp
390    FOR I=1 TO Var2
400      Ib=Ib1+(I-1)*Ib2
410      OUTPUT @Hp415x;"PI ";Base,Range,Ib_base,Ib,Vb_comp
420      OUTPUT @Hp415x;"XE"
430      OUTPUT @Hp415x;"*OPC?"
440      ENTER @Hp415x;C
450      OUTPUT @Hp415x;":SYST:ERR?"
460      ENTER @Hp415x;C,C$
470      IF C<>0 THEN
480        PRINT "ERROR:";C,C$
490        BEEP
500        DISP "Press Continue to read data. Or press Stop."
510        PAUSE
520        DISP ""
530      END IF
540     !
```

Line Number	Description
320	Enables the measurement units.
330	Sets the timing parameters of the pulse source (base current).
340	Sets the sweep with pulsed bias measurement mode.
350	Enables measurement abort function for abnormal conditions.
360	Sets the staircase sweep source (Vc).
370	Sets the measurement range (Ic).
380	Forces the dc voltage (Ve).
400	Calculates the base current peak value.
410	Sets the pulsed bias (Ib).
420 to 440	Executes a staircase sweep with pulsed bias measurement.
450 to 530	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.

```
550   ! Reading data
560      OUTPUT @Hp415x;"NUB?"
570      ENTER @Hp415x;C
580      IF C<>0 THEN
590        PRINT "Ib=";Ib*1.E+6;"(uA)"
600        FOR N=1 TO C
610          OUTPUT @Hp415x;"RMD? 1"
620         ENTER @Hp415x USING "#,3A,A,A,13D,X";St$,Ch$,Md$,Mdata
630          IF Md$="I" THEN
640            PRINT " Ic=";Mdata*1000;"(mA), Status=";St$
650          ELSE
660            IF Md$="v" THEN
670              PRINT " Vc=";Mdata;"(V), Status=";St$
680            ELSE
690              PRINT " XX=INVALID DATA, Status=";St$
700            END IF
710          END IF
720        NEXT N
730      ELSE
740        PRINT "STATUS: No data returned."
750      END IF
760    NEXT I
770    OUTPUT @Hp415x;"CL"
780    OUTPUT @Hp415x;":PAGE"
790    END
```

Line Number	Description
560 to 570	Confirms the number of data stored in the output buffer.
610 to 680	Reads the measurement data, and displays the measurement data.
690	Displays “XX=INVALID DATA” if the data is not the current measurement data or the voltage output data.
740	Displays “No data returned” if the number of data is zero.
770	Disables the measurement units.
780	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

Sampling Measurements

To make sampling measurements, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets Filter ON/OFF	[FL]	*mode*[,*chnum* ... [,*chnum*] ...]
Sets Averaging Number	[AV] [a]	*number*[,*mode*]
Sets Integration Time	[SIT]	*type*,*time*
	[SLI] [a]	*type*
Sets the timing parameters	MT	*hold*,*interval*,*points*
Source setup	MV	*ch*,*range*,*base*,*bias*[,*Icomp*]
	MI	*ch*,*range*,*base*,*bias*[,*Vcomp*]
	MP	*ch*,*mode*,*base*,*bias*[,*Td*,*Tw*,*Tl*,*Tt*,*Tp*,*count*] [b]
Clears the sampling source settings	[MCC]	[*ch*[,*ch* ... [,*ch*[,*ch*]] ...]]
Sets automatic abort condition	[MSC]	*abort*
Forces constant voltage	[DV]	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	[DI]	*chnum*,*range*,*output*[,*Vcomp*]
Sets VMU measurement mode	[VM]	*chnum*,*mode*
Sets voltage measurement range	[RV]	*chnum*,*range*[,*Rmode*]

Function	FLEX Command	Parameters
Sets current measurement range	[RI]	*chnum*,*range*[,*Rmode*]
	[RM]	*chnum*,*mode*[,*rate*]
Selects measurement mode	MM	10,*chnum*[,*chnum* ..[,*chnum*] ..] [c]
Sets SMU measurement mode	[CMM]	*chnum*,*mode*
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

a. If the MT command *interval* parameter is less than 2 msec, the AV and SLI commands are ignored.
b. The *Tp* and *count* settings are effective for both PGU1 and PGU2. The latest value is effective for the output pulse.
c. If the MT command *interval* parameter is less than 2 msec, the available number of *chnum*s is 1.

A program example of a sampling measurement is shown below. This program executes the resistance measurements and prints the results on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER High,Low,Range_v,Range_i,Nop
40      DIM C$[100]
50      High=1          !1:SMU1
60      Low=2           !2:SMU2
70      Hold=1          !Hold time (sec)
80      Interval=.5     !Sampling interval (sec)
90      Nop=11          !Number of sampling points
100     Vbase=0         !Base voltage for High
110     Vbias=10        !Bias voltage for High
120     Icomp=.001      !Current compliance
130     Vl=0            !Voltage for Low
140     Range_v=12      !12:20 V Limited Auto Ranging
150     Range_i=14      !14: 1uA Limited Auto Ranging
160   !
170     OUTPUT @Hp415x;"US"
180     OUTPUT @Hp415x;"FMT 1,1"      !Data w/Header, Index
190     OUTPUT @Hp415x;"CN ";High,Low
200     OUTPUT @Hp415x;"MSC 2"        !Stops for any abort condition
210     OUTPUT @Hp415x;"MCC"
220     OUTPUT @Hp415x;"MT ";Hold,Interval,Nop
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
50 to 150	Sets the measurement parameters.
170	Enters the 4155C/4156C FLEX command control mode.
180	Specifies the data output format.
190	Enables the measurement units.
200	Sets the automatic abort condition.
210	Clears the previous sampling setup.
220	Sets the sampling measurement timing parameters.

```
230    OUTPUT @Hp415x;"MM 10,";High !Sampling measurement
240    OUTPUT @Hp415x;"MV ";High,Range_v,Vbase,Vbias,Icomp
250    OUTPUT @Hp415x;"DV ";Low,Range_v,Vl,Icomp
260    OUTPUT @Hp415x;"RI ";High,Range_i
270    OUTPUT @Hp415x;"XE"
280    OUTPUT @Hp415x;"*OPC?"
290    ENTER @Hp415x;C
300    OUTPUT @Hp415x;"CL"
310    OUTPUT @Hp415x;":SYST:ERR?"
320    ENTER @Hp415x;C,C$
330    IF C<>0 THEN
340      PRINT "ERROR:";C,C$
350      BEEP
360      DISP "Press Continue to read data. Or press Stop."
370      PAUSE
380      DISP ""
390    END IF
400     !
```

Line Number	Description
230	Sets the sampling measurement mode.
240	Sets the voltage source synchronized with the sampling measurements.
250	Forces the dc voltage to the Low terminal.
260	Sets the measurement range.
270 to 290	Executes the sampling measurements.
300	Disables the measurement units.
310 to 390	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.

```
410   ! Reading data
420    OUTPUT @Hp415x;"NUB?"
430    ENTER @Hp415x;C
440    IF C<>0 THEN
450      FOR N=1 TO C
460        OUTPUT @Hp415x;"RMD? 1"
470        ENTER @Hp415x USING "#,3A,A,A,13D,X";St$,Ch$,Md$,Mdata
480        IF Md$="p" THEN
490          PRINT "INDEX=";Mdata
500        ELSE
510          IF Md$="I" THEN
520            PRINT " R=";Vbias/Mdata;"(ohm), Status=";St$
530          ELSE
540            PRINT " XX=INVALID DATA, Status=";St$
550          END IF
560        END IF
570      NEXT N
580    ELSE
590      PRINT "STATUS: No data returned."
600    END IF
610    OUTPUT @Hp415x;":PAGE"
620    END
```

Line Number	Description
420 to 430	Confirms the number of data stored in the output buffer.
460 to 530	Reads the measurement data, and displays the measurement data.
540	Displays “XX=INVALID DATA” if the data is not the index data or the current measurement data.
590	Displays “No data returned” if the number of data is zero.
610	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

Quasi-static CV Measurements

To make quasi-static CV measurements, use the following commands.

Function	FLEX Command	Parameters
Enables measurement units	CN	[*chnum* ... [,*chnum*] ...]
Disables measurement units	CL	[*chnum* ... [,*chnum*] ...]
Turns the filter on/off	[FL]	*onoff*[,*chnum* ... [,*chnum*] ...]
Sets the measurement mode	MM	13[,*chnum*]
Sets zero cancel	[QSZ]	*onoff*
Sets the leak measurement/ leak compensation	[QSL]	*data_onoff*,*compen_onoff*
Sets the abort function	[QSM]	*condition*[,*result*]
Sets the measurement range	QSR	*range*
Sets the timing parameters	QST	*cinteg*,*linteg*,*hold*,*delay1* [,*delay2*]
Sets the sweep source	QSV	*chnum*,*swpmode*,*range*,*start*,*stop* ,*cvoltage*,*step*[,*Icomp*]
Forces the constant source	DV	*chnum*,*range*,*output*[,*Icomp*]
Executes a measurement	XE	
Reads the measurement data	RMD?	*number_of_data*

A program example of quasi-static CV measurement is shown below. This program measures the gate capacitance of MOSFET, and displays the data on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Drain,Gate,Sub,Source,Rm,Ro,Swp,Var1
40      DIM A$[100]
50      Drain=1         ! 1: SMU1
60      Gate=2          ! 2: SMU2
70      Sub=3           ! 3: SMU3
80      Source=4        ! 4: SMU4
90      Rm=-11          ! -11: 1 nA fixed range
100     Ro=0            ! 0: Auto ranging
110     Swp=1           ! Single sweep
120     Hold=1          ! Hold time (sec)
130     Delay=0         ! Delay time (sec)
140     Integ_c=.1      ! Integ time (sec) for C measurement
150     Integ_l=.1      ! Integ time (sec) for Leakage measurement
160     Vg1=3.2         ! Sweep start voltage (V)
170     Vg2=-3.2        ! Sweep stop voltage (V)
180     Vstep=-.2       ! Sweep step voltage (V)
190     Vcap=.2         ! QSCV measurement voltage (V)
200     G_comp=.01      ! Current compliance (A) for Gate
210     Var1=ABS(Vg1-Vg2)/ABS(Vstep)-1  ! Number of steps
220    !
230     OUTPUT @Hp415x;"US"
240     OUTPUT @Hp415x;"FMT 1,1"      !Data w/Header,Source_data
250     OUTPUT @Hp415x;"MM 13,";Gate !QSCV measurement
260     OUTPUT @Hp415x;"CN ";Sub,Source,Drain,Gate
270     OUTPUT @Hp415x;"QSL 1,1"      !Enables leak data/compen
280     OUTPUT @Hp415x;"QSM 2,1"      !Stops for any abort condition
290     OUTPUT @Hp415x;"QSR ";Rm
```

Line Number	Description
10	Assigns the I/O path for controlling the 4155C/4156C.
50 to 200	Sets the measurement parameters.
210	Calculates the number of steps for the voltage sweep.
230	Enters the 4155C/4156C FLEX command control mode.
240	Specifies the data output format.
250 to 260	Sets the quasi-static CV measurement mode and its measurement channel. And closes the SMU input switches.
270	Enables leakage current measurement and compensation.
280	Enables measurement abort function for abnormal conditions.
290	Sets the measurement range.

```
300     OUTPUT @Hp415x;"QST ";Integ_c,Integ_l,Hold,Delay,0
310     OUTPUT @Hp415x;"DV ";Drain,Ro,0,.1
320     OUTPUT @Hp415x;"DV ";Sub,Ro,0,.1
330     OUTPUT @Hp415x;"DV ";Source,Ro,0,.1
340     OUTPUT @Hp415x;"QSV ";Gate,Swp,Ro,Vg1,Vg2,Vcap,Var1,G_comp
350     DISP "Open measurement terminals. Then press Continue."
360     BEEP
370     PAUSE
380     DISP "Offset measurement is in progress."
390     OUTPUT @Hp415x;"QSZ 2"        !Executes offset measurement
400     OUTPUT @Hp415x;"RMD? 1"       !Reads offset data
410     ENTER @Hp415x USING "#,5X,13D,X";Dzero
420     PRINT "Offset Data=";Dzero*1.E+12;"pF"
430     PRINT "*******************************************"
440     BEEP
450     DISP "Connect your DUT. Then press Continue."
460     OUTPUT @Hp415x;"QSZ 1"        !Enables zero cancel
470     PAUSE
480     DISP "QSCV measurement is in progress."
490     OUTPUT @Hp415x;"XE"
500     OUTPUT @Hp415x;"*OPC?"
510     ENTER @Hp415x;A
520     OUTPUT @Hp415x;"CL"
530     DISP ""
540     OUTPUT @Hp415x;":SYST:ERR?"
550     ENTER @Hp415x;A,A$
560     IF A<>0 THEN
570       PRINT "ERROR:";A,A$
580       BEEP
590       DISP "Press press Continue to read data. Or press Stop."
600       PAUSE
610       DISP ""
620     END IF
```

Line Number	Description
300	Sets the integration time, hold time, and delay time.
310 to 330	Sets the dc source output for the MOSFET drain, source, and substrate terminals.
340	Sets the sweep source output for the MOSFET gate terminal.
350 to 470	Executes the offset measurement, and enables the zero cancel.. Before execute the offset measurement, DUT must be removed from the measurement terminals.
480 to 510	Executes a quasi-static CV measurement.
520	Opens the SMU input switches.
540 to 620	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.

```
630    !
640    ! Reading data
650     OUTPUT @Hp415x;"NUB?"
660     ENTER @Hp415x;A
670     IF A<>0 THEN
680       FOR I=1 TO A
690         OUTPUT @Hp415x;"RMD? 1"
700         ENTER @Hp415x USING "#,3A,X,A,13D,X";A$,B$,Mdata
710         IF B$="I" THEN
720           PRINT "INDEX=";INT((I+2)/3)
730           PRINT " Leak=";Mdata*1.E+12;"(pA), Status=";A$
740         ELSE
750           IF B$="C" THEN
760             PRINT " Cap=";Mdata*1.E+12;"(pF), Status=";A$
770           ELSE
780             IF B$="v" THEN
790               PRINT " Vg=";Mdata;"(V), Status=";A$
800             ELSE
810               PRINT " XX=INVALID DATA, Status=";A$
820             END IF
830           END IF
840         END IF
850       NEXT I
860     ELSE
870       PRINT "STATUS: No data returned."
880     END IF
890    ! OUTPUT @Hp415x;":PAGE"
900     END
```

Line Number	Description
650 to 660	Confirms the number of data stored in the output buffer.
690 to 700	Reads the measurement data.
710 to 730	Displays the data index and the leakage current measurement data.
750 to 760	Displays the capacitance measurement data.
780 to 790	Displays the source output voltage.
810	Displays “XX=INVALID DATA” if the data is not the current measurement data, capacitance measurement data, or the voltage output data.
870	Displays “No data returned” if the number of data is zero.
890	Returns the 4155C/4156C to the default control mode (SCPI command control mode) if the exclamation mark of the line is removed.

Linear Search Measurements

To make linear search measurements, use the following commands.

Function	FLEX Command	Parameters
Enables measurement units	CN	[*chnum* ... [,*chnum*] ...]
Disables measurement units	CL	[*chnum* ... [,*chnum*] ...]
Sets filter on/off	[FL]	*onoff*[,*chnum* ... [,*chnum*] ...]
Sets measurement mode	MM	14
Selects output data	[LSVM]	*output_data*
Sets timing parameters	[LSTM]	*holdtime*,*delaytime*
Sets the abort function	[WM]	*abort*[,*post*]
Sets current search or voltage search condition	LGI or LGV	*chnum*,*mode*,*range*,*target*
Sets voltage source or current source	LSV or LSI	*chnum*,*range*,*start*,*stop*,*step* [,*comp*]
Sets synchronous voltage source or current source	[LSSV] or [LSSI]	*chnum*,*polarity*,*offset*[,*comp*]
Forces constant source	DV or DI	*chnum*,*range*,*output*[,*comp*]
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

Before sending the LSSI command, the LSI command must be sent. Do not use the LSV command.

Before sending the LSSV command, the LSV command must be sent. Do not use the LSI command.

A program example of a linear search measurement is shown below. This program executes MOSFET threshold voltage measurement, and displays the result data on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Gate,Drain,Source,Sub,Rm,Ro,Judge,Posneg
40      DIM A$[100]
50      Drain=1         ! 1: SMU1
60      Gate=2          ! 2: SMU2
70      Sub=3           ! 3: SMU3
80      Source=4        ! 4: SMU4
90      V_b=.5          ! Search start voltage (V)
100     V_e=1           ! Search stop voltage (V)
110     V_s=.01         ! Search step voltage (V)
120     D_comp=.01      ! Drain compliance (A)
130     G_comp=.01      ! Gate compliance (A)
140     Rm=14           ! 14: 1 uA limited auto ranging
150     Ro=11           ! 11: 2 V limited auto ranging
160     Hold=0          ! Hold time (s)
170     Delay=0         ! Delay time (s)
180     Judge=1         ! 1: Meas >= Target
190     Target=1.E-6    ! Target value
200     Posneg=1        ! 1: Positive, 0: Negative
210     Offset=0        ! Offset voltage (V)
220    !
230     OUTPUT @Hp415x;"US"
240     OUTPUT @Hp415x;"FMT 1,1"! Data w/Header,Source_data
250     OUTPUT @Hp415x;"MM 14"  ! Linear search
260     OUTPUT @Hp415x;"WM 2,1" ! Stops for any abnormal condition
270     OUTPUT @Hp415x;"LSVM 1" ! 0: Target, 1: w/data
```

Line Number	Description
10	Assigns the I/O path for controlling the 4155C/4156C.
50 to 210	Sets the measurement parameters.
230	Enters the 4155C/4156C FLEX command control mode.
240	Specifies the data output format.
250	Sets the linear search measurement mode.
260	Enables measurement abort function for abnormal conditions.
270	Sets all result data output mode.

```
280    OUTPUT @Hp415x;"LSTM ";Hold,Delay
290    OUTPUT @Hp415x;"LGI ";Drain,Judge,Rm,Target
300   !
310    OUTPUT @Hp415x;"CN ";Source,Drain,Gate,Sub
320    OUTPUT @Hp415x;"DV ";Source,Ro,0,.01
330    OUTPUT @Hp415x;"DV ";Sub,Ro,0,.01
340    OUTPUT @Hp415x;"LSV ";Drain,Ro,V_b,V_e,V_s,D_comp
350    OUTPUT @Hp415x;"LSSV ";Gate,Posneg,Offset,G_comp
360    OUTPUT @Hp415x;"XE"
370    OUTPUT @Hp415x;"*OPC?"
380    ENTER @Hp415x;A
390    OUTPUT @Hp415x;"CL"
400    OUTPUT @Hp415x;":SYST:ERR?"
410    ENTER @Hp415x;A,A$
420    IF A<>0 THEN
430      PRINT "ERROR:";A,A$
440      BEEP
450      DISP "Press press Continue to read data. Or press Stop."
460      PAUSE
470      DISP ""
480    END IF
490   !
```

Line Number	Description
280	Sets hold time and delay time.
290	Sets current search condition.
310	Closes the SMU input switches.
320 to 330	Sets the dc source output for the MOSFET source and substrate terminals.
340	Sets the sweep source output for the MOS FET drain terminal.
350	Sets the synchronous sweep source output for the MOS FET gate terminal.
360 to 380	Executes a linear search measurement.
390	Opens the SMU input switches.
400 to 480	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.

```
500   ! Reading data
510    OUTPUT @Hp415x;"NUB?"
520    ENTER @Hp415x;A
530    IF A<>0 THEN
540      PRINT "Raw data ************************************"
550      FOR I=1 TO A-2
560        OUTPUT @Hp415x;"RMD? 1"
570        ENTER @Hp415x USING "#,3A,X,A,13D,X";A$,B$,Mdata
580        IF B$="v" THEN
590          PRINT "INDEX=";INT((I+1)/2)
600          PRINT " Vg=";Mdata;"(V), Status=";A$
610        ELSE
620          IF B$="I" THEN
630            PRINT " Id=";Mdata*1.E+6;"(uA), Status=";A$
640          ELSE
650            IF B$="S" THEN
660              IF Mdata=0 THEN
670               PRINT "Search result **************************"
680                OUTPUT @Hp415x;"RMD? 2"
690                ENTER @Hp415x USING "#,5X,13D,6X,13D,X";D1,D2
700                PRINT "Vth=";D1;"V at Id=";D2*1.E+6;"uA"
710              ELSE
720                PRINT "No target found."
730              END IF
740            ELSE
750              PRINT " XX=INVALID DATA, Status=";A$
760            END IF
770          END IF
780        END IF
790      NEXT I
800    ELSE
810      PRINT "STATUS: No data returned."
820    END IF
830   ! OUTPUT @Hp415x;":PAGE"
840    END
```

Line Number	Description
510 to 520	Confirms the number of data stored in the output buffer.
560 to 570	Reads the measurement data.
580 to 780	Displays the raw data and the search result data on the screen.
830	Returns the 4155C/4156C to the default control mode (SCPI command control mode) if the exclamation mark of the line is removed.

Binary Search Measurements

To make binary search measurements, use the following commands.

Function	FLEX Command	Parameters
Enables measurement units	CN	[*chnum* ... [,*chnum*] ...]
Disables measurement units	CL	[*chnum* ... [,*chnum*] ...]
Sets filter on/off	[FL]	*onoff*[,*chnum* ... [,*chnum*] ...]
Sets measurement mode	MM	15
Selects output data	[BSVM]	*output_data*
Sets timing parameters	[BST]	*holdtime*,*delaytime*
Sets source control mode	BSM	*mode*
Sets current search or voltage search condition	BGI or BGV	*chnum*,*mode*,*condition*,*range*, *target*
Sets voltage source or current source	BSV or BSI	*chnum*,*range*,*start*,*stop*[,*comp*]
Sets synchronous voltage source or current source	[BSSV] or [BSSI]	*chnum*,*polarity*,*offset*[,*comp*]
Forces constant source	DV or DI	*chnum*,*range*,*output*[,*comp*]
Executes measurement	XE	
Reads measurement data	RMD?	*number_of_data*

Before sending the BSSI command , the BSI command must be sent. Do not use the BSV command.

Before sending the BSSV command, the BSV command must be entered. Do not use the BSI command.

A program example of a binary search measurement is shown below. This program executes MOSFET threshold voltage measurement, and prints result data on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Gate,Drain,Source,Sub,Nub,I
40      INTEGER V_n,Rm,Ro,Posneg,Offset
50      DIM C$[50]
60      Source=1        ! 1: SMU1
70      Drain=2         ! 2: SMU2
80      Gate=3          ! 3: SMU3
90      Sub=4           ! 4: SMU4
100     V_b=.5          ! Search start voltage (V)
110     V_e=1           ! Search stop voltage (V)
120     D_comp=.01      ! Drain compliance (A)
130     G_comp=.01      ! Gate compliance (A)
140     Rm=14           ! 14: 1 uA limited auto ranging
150     Ro=11           ! 11: 2 V limited auto ranging
160     Hold=0          ! Hold time (s)
170     Delay=0         ! Delay time (s)
180     Mode=0          ! 0: Limit, 1: Repeat
190     Judge=1.E-8     ! Limit in A. for Limit mode.
200    !Judge=10        ! No of repeats. for Repeat mode.
210     Target=1.E-6    ! Target value
220     Posneg=1        ! 1: Positive, 0: Negative
230     Offset=0        ! Offset voltage (V)
240    !
250     OUTPUT @Hp415x;"US"
260     OUTPUT @Hp415x;"FMT 1"  ! ASCII w/header
270     OUTPUT @Hp415x;"MM 15"  ! Binary search
280     OUTPUT @Hp415x;"BSM 1"  ! 1: SAFE
290     OUTPUT @Hp415x;"BSVM 1" ! 0: Target, 1: w/data
```

Line Number	Description
10	Assigns the I/O path for controlling the 4155C/4156C.
60 to 230	Sets the measurement parameters.
270	Sets the binary search measurement mode.
280	Sets source control mode to cautious mode.
290	Sets all result data output mode.

```
300    OUTPUT @Hp415x;"BST ";Hold,Delay
310    OUTPUT @Hp415x;"BGI ";Drain,Mode,Judge,Rm,Target
320   !
330    OUTPUT @Hp415x;"CN ";Source,Drain,Gate,Sub
340    OUTPUT @Hp415x;"DV ";Source,Ro,0,.01
350    OUTPUT @Hp415x;"DV ";Sub,Ro,0,.01
360    OUTPUT @Hp415x;"BSV ";Drain,Ro,V_b,V_e,D_comp
370    OUTPUT @Hp415x;"BSSV ";Gate,Posneg,Offset,G_comp
380    OUTPUT @Hp415x;"XE"
390    OUTPUT @Hp415x;"*OPC?"
400    ENTER @Hp415x;B
410    OUTPUT @Hp415x;"CL"
420   !
430    OUTPUT @Hp415x;":SYST:ERR?"
440    ENTER @Hp415x;C,C$
450    IF C=0 THEN
460      GOTO 520
470    ELSE
480      PRINT C,C$
490      GOTO 730
500    END IF
510   !
```

Line Number	Description
300	Sets the hold time and delay time.
310	Sets the current search condition.
330	Closes the SMU input switches.
340 to 350	Sets the dc source output for the MOSFET source and substrate.
360	Sets the binary search output for the MOSFET drain terminal.
370	Sets the synchronous binary search output for the gate terminal.
380 to 400	Executes a binary search measurement.
410	Opens the SMU input switches.
430 to 500	Checks to see if an error has occurred. If an error is detected, the error code and error message are displayed on the screen.

```
520    OUTPUT @Hp415x;"NUB?"
530    ENTER @Hp415x;Nub
540    IF Nub<>INT((Nub-3)/2)*2+3 THEN
550      DISP Nub;"data returned. No. of data must be N*2+3."
560      GOTO 730
570    ELSE
580      OUTPUT @Hp415x;"RMD?"
590      PRINT "Raw data ************************************"
600      FOR I=1 TO (Nub-3)/2
610        ENTER @Hp415x USING "#,5X,13D,6X,13D,X";A,B
620        PRINT I;"Vg=";A;", Id=";B
630      NEXT I
640      PRINT "Search result ******************************"
650      ENTER @Hp415x USING "#,5X,13D,6X,13D,6X,13D,X";St,A,B
660      IF St=0 THEN
670        PRINT "Vth=";A;"V at Id=";B*1.E+6;"uA"
680        PRINT "Search target=";Target*1.E+6;"uA
+/-";Judge*1.E+6;"uA"
690      ELSE
700        PRINT "No target found."
710      END IF
720    END IF
730    !OUTPUT @Hp415x;":PAGE"
740    END
```

Line Number	Description
520 to 530	Confirms the number of data stored in the output buffer.
580	Reads the all measurement data.
590 to 630	Displays the raw data on the screen.
640 to 680	Displays the search result data on the screen.
700	Displays “No target found” if the status code of the search status data is not 0.
730	Returns the 4155C/4156C to the default control mode (SCPI command control mode) if the exclamation mark of the line is removed.

Stress Force

To utilize the stress force function, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets PGU output impedance	POR	*chnum*,*impedance*
Sets stress mode/stress time	STT	*hold*,*mode*[,*count*[,*period*]] [a]
Stress source setup	STV	*source*,*chnum*,*range*,*base*,*stress* [,*Icomp*]
	STI	*source*,*chnum*,*range*,*base*,*stress* [,*Vcomp*]
	STP	*source*,*chnum*,*mode*,*base*,*stress* [,*Td*[,*Tw*[,*Tl*[,*Tt*]]]]
Clears stress source setup	STC	[*source*[,*source*[,*source*[,*source*]]]]
Sets automatic abort condition	STM [b]	*abort*
Forces constant voltage	[DV]	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	[DI]	*chnum*,*range*,*output*[,*Vcomp*]
Selects measurement mode	MM	11
Executes measurement	XE	

a. The *count* and *period* settings are effective for both PGU1 and PGU2. The latest setting is effective for the output pulse.

b. The automatic abort function is available when the STT command sets the freerun pulse stress mode or the pulse count stress mode. For the pulse count stress mode, the pulse output must be more than 10 sec (*count* × *period* >10 sec) to use the automatic abort function.

The stress force starts with the XE command and stops when the STT command setting or the STM command setting is satisfied. To stop the stress force immediately, enter the AB command.

A program example of stress force is shown below. This program forces dc stress using SMU and pulse stress using PGU. It does *not* execute the measurements.

```
10      ASSIGN @Hp415x TO 800
20    !
30      INTEGER Drain,Sub,Source,G1,G2,Mmode,Status
40      INTEGER Impedance,Smode,Pmode,Range_v,B,C
50      DIM B$[50]
60    !
70      Drain=1         !1:SMU1
80      Sub=2           !2:SMU2
90      Source=26       !26:GNDU
100     G1=3            !3:SMU3
110     G2=27           !27:PGU1
120     Impedance=0     !0:Low impedance. 1:50 ohm
130     Abort=2         !2:Selects all abort condition
140     Range_v=12      !12:20 V Limited Auto Ranging
150     Base=0          !Stress base voltage
160     Bias=10         !Dc stress voltage
170     Icomp_g=.01     !Current compliance for gate (G1)
180     Smode=1         !Stress mode of PGU. 0:dc, 1:Pulse
190     Pulse=10        !Pulse stress voltage
200     Td=.03          !Pulse delay (sec)
210     Tw=.05          !Pulse width (sec)
220     Tl=.001         !Pulse leading time (sec)
230     Tt=.001         !Pulse trailing time (sec)
240     Tp=.1           !Pulse period (sec)
250     Hold=0          !Hold time
260     Pmode=1         !Pulse mode. 0:Free, 1:Count, 2:Duration
270     Count=1000      !Pulse count
280     Vd=5            !Drain Voltage
290     Vsub=0          !Substrate Voltage
300     Icomp=.1        !Current compliance
310     Mmode=11        !11:Stress Force
320   !
330     OUTPUT @Hp415x;"US"
340     OUTPUT @Hp415x;"STC"
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
70 to 310	Sets the parameters.
330	Enters the 4155C/4156C FLEX command control mode.
340	Clears the previous stress condition.

```
350    OUTPUT @Hp415x;"CN ";Drain,G1,G2,Sub
360    OUTPUT @Hp415x;"POR ";G2,Impedance
370    OUTPUT @Hp415x;"STM ";Abort
380    OUTPUT @Hp415x;"STT ";Hold,Pmode,Count,Tp
390    OUTPUT @Hp415x;"STV 0,";G1,Range_v,Base,Bias,Icomp_g
400    OUTPUT @Hp415x;"STP 1,";G2,Smode,Base,Pulse,Td,Tw,Tl,Tt
410    OUTPUT @Hp415x;"DV ";Sub,Range_v,Vsub,Icomp
420    OUTPUT @Hp415x;"DV ";Drain,Range_v,Vd,Icomp
430    OUTPUT @Hp415x;"MM ";Mmode
440    OUTPUT @Hp415x;"XE"
450    OUTPUT @Hp415x;"*OPC?"
460    ENTER @Hp415x;C
470  !
480    OUTPUT @Hp415x;"RMD? 1"
490    ENTER @Hp415x USING "#,3D,15X,X";Status
500    PRINT "STATUS=";Status
510    OUTPUT @Hp415x;"CL"
520    OUTPUT @Hp415x;":SYST:ERR?"
530    ENTER @Hp415x;B,B$
540    PRINT "ERROR:";B$
550  !
560    OUTPUT @Hp415x;":PAGE"
570    END
```

Line Number	Description
350	Enables the stress and bias sources.
360	Sets the output impedance of the PGU.
370	Sets the automatic abort condition.
380	Sets the stress mode and stress time.
390	Sets the dc voltage stress source.
400	Sets the pulse stress source.
410 to 420	Forces the dc voltage to Drain and Sub.
430	Sets the stress force mode.
440 to 460	Forces the stress set by the STV and STP commands.
480 to 500	Checks status of stress force completion
510	Disables the measurement units.
520 to 540	Checks for errors.
560	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Controlling PGU

To control PGU, use the following commands.

Function	FLEX Command	Parameters
Enables Measurement Units	CN	[*chnum* ... [,*chnum*] ...]
Disables Measurement Units	CL	[*chnum* ... [,*chnum*] ...]
Sets PGU output impedance	POR	*chnum*,*impedance*
Sets output mode	SPG	*chnum*,*mode*[,*base*[,*pulse*,*Td*,*Tw*,*Tl*,*Tt*,*Tp*,*Pc*]] [a]
Starts PGU output force	SRP	
Stops PGU output force	SPP	
Forces constant voltage	[DV]	*chnum*,*range*,*output*[,*Icomp*]
Forces constant current	[DI]	*chnum*,*range*,*output*[,*Vcomp*]

a. The *Tp* and *Pc* settings are effective for both PGU1 and PGU2. The latest setting is effective for the output pulse.

The PGU output can be controlled by the SPG/SPR/SPP commands. It is *not* controlled by the XE command. You can use the PGU control commands, regardless of the measurement mode (MM command setting).

To force PGU output, use the SRP command.

To stop PGU output, use the SPP command. The PGU output will then go to the *base* value. To force 0 V, use the DV command.

A program example of PGU output control is shown below. This program forces constant voltage by using PGU1, forces voltage pulse by using PGU2, and executes the high-speed spot measurements.

```
10      ASSIGN @Hp415x TO 800
20    !
30      INTEGER Fmt,Drain,Source,Gate,Sub,M1,M2,Pc,A
40      INTEGER Range_v,Range_i
50      DIM A$[50]
60    !
70      Fmt=1           !1:ASCII with header <LF^EOI>
80      Drain=1         !1:SMU1
90      Source=26       !26:GNDU
100     Gate=27         !27:PGU1
110     Sub=28          !28:PGU2
120     Impedance=0     !0:Low impedance, 1:50 ohm
130     M1=1            !Output mode for Sub   1:constant
140     M2=2            !Output mode for Gate  2:pulse
150     B1=0            !Constant voltage for Sub
160     B2=2.5          !Pulse base voltage for Gate
170     Out=5           !Pulse voltage for Gate
180     Td=.03          !Pulse delay (sec)
190     Tw=.05          !Pulse width (sec)
200     Tl=.001         !Pulse leading time (sec)
210     Tt=.001         !Pulse trailing time (sec)
220     Tp=.1           !Pulse period (sec)
230     Pc=0            !Pulse count  0: free run
240     Range_v=12      !12: 20 V Limited Auto Ranging
250     Vd=5            !Drain Voltage
260     Vsub=0          !Substrate Voltage
270     Icomp=.1        !Current compliance
280     Range_i=14      !14: 1 uA Limited Auto Ranging
290   !
300     OUTPUT @Hp415x;"US"
310     OUTPUT @Hp415x;"FMT ";Fmt
320     OUTPUT @Hp415x;"CN ";Drain,Gate,Sub
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
70 to 280	Sets the parameters.
300	Enters the 4155C/4156C FLEX command control mode.
310	Specifies the data output format.
320	Enables the PGUs and measurement units.

```
330    OUTPUT @Hp415x;"POR ";Sub,Impedance
340    OUTPUT @Hp415x;"POR ";Gate,Impedance
350    OUTPUT @Hp415x;"SPG ";Sub,M1,B1
360    OUTPUT @Hp415x;"SPG ";Gate,M2,B2,Out,Td,Tw,Tl,Tt,Tp,Pc
370    OUTPUT @Hp415x;"DV ";Drain,Range_v,Vd,Icomp
380    OUTPUT @Hp415x;"SRP"
390  !
400    OUTPUT @Hp415x;":SYST:ERR?"
410    ENTER @Hp415x;A,A$
420    IF A=0 THEN
430      FOR I=1 TO 10
440        OUTPUT @Hp415x;"TI? ";Drain,Range_i
450        ENTER @Hp415x USING "#,5X,13D,X";Mdata
460        PRINT "Id(A)=";Mdata
470        WAIT 1
480      NEXT I
490    END IF
500  !
510    OUTPUT @Hp415x;"SPP"
520    OUTPUT @Hp415x;"DV ";Gate,0,0
530    OUTPUT @Hp415x;"DV ";Drain,0,0
540    PRINT A,A$
550    OUTPUT @Hp415x;"CL"
560    OUTPUT @Hp415x;":PAGE"
570    END
```

Line Number	Description
330 to 340	Sets the PGU output impedance.
350	Sets the PGU setup for Substrate.
360	Sets the PGU setup for Gate.
370	Forces the dc voltage to Drain.
380	Forces the PGU output.
400 to 410	Checks for errors.
440 to 460	Measures the drain current and prints the results on the screen.
510	Stops the PGU pulse output.
520 to 530	Forces 0 V to Gate and Drain.
540	Prints an error code and error message on the screen.
550	Disables the measurement units.
560	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Using Program Memory

Storing and executing measurement programs from internal memory improves measurement speed. The following commands are available for use in program memory.

Function	FLEX Command	Parameters
Stores the command into program memory	ST, END	ST *prog No.*;*command*[... [;*command*] ..] END
		ST *prog No.* [*command*] : : [*command*] END
Scratches the program	SCR	[*prog No.*]
Gets a list of programs or a specific program listing	LST?	[*prog No.*]
Executes specified programs	DO	*prog No.*[,*prog No.* ... [,*prog No.*] ...]
Executes programs sequentially	RU	*start*,*stop*
Pauses command execution or internal memory program execution	PA	[*wait time*]

The program memory can store a maximum of 255 programs (a maximum of 100 KB).

The program memory is available when the 4155C/4156C is in the FLEX command control mode. The internal memory programs are deleted when the US or US42 command is executed.

The internal memory does not provide for error checking, so programs must be complete and free of errors before they are stored.

If the program being stored makes changes to the present measurement setup, verify that these changes are correct and compatible with the present setup before storing the FLEX commands in the program memory.

If the program you will be storing executes a measurement, verify the program is free of errors and runs correctly before storing it in the program memory.

Other notes:

1. Invalid commands in the internal memory program:

```
AB        ACH
CA        CLOSE     CM        *CAL?     *CLS?
DO        END       ERR?      *ESE?
*IDN?     LOP?      LST?      *LRN?
NUB?      OPEN      *OPC(?)   *OPT?     PRN       QSZ/QSZ?
RCV       RD?       RMD?      RU        *RST
SCR       SDSK      SPL       SPR       ST
*SRE?     *STB?     :SYST:ERR?
*TST?     UNT?      US        US42
WNU?      WR        *WAI
```

2. Command parameters:

   When entering FLEX commands in internal memory, some optional parameters are required. You must specify both the necessary command parameters and these optional parameters. For more information regarding necessary parameters, refer to Chapter 1 of the *GPIB Command Reference*.

3. For 1 channel pulsed spot, pulsed sweep, and staircase sweep with pulsed bias measurements:

   Multi-channel measurements are available when the PT command *priority* parameter is set to "wait for measurement completion". If the parameter is set to "keep pulse width", only one measurement channel is available.

   If you change the *priority* parameter value and do *not* change the MM command parameter, the returned measurement data is available only for the first channel defined in the MM command. The data for the other channels will not be valid.

4. For sampling measurements:

   Multi-channel measurements are available. If the sampling interval is less than 2 msec, only one measurement channel is available.

   If you change the sampling interval to a value less than 2 msec, the returned measurement data is available only for the first channel defined in the MM command. The data for the other channels will not be valid.

5. For synchronous sweep measurements:

   The secondary sweep channel must be defined after the primary sweep channel. Enter the WSI/WSV command after the WI/WV or PWI/PWV command.

6. For PGU pulse output:

   If you use two PGUs, set the pulse period and pulse count parameters for the STT, SPG or MP command carefully. If you enter the command to change these parameter values, the previous settings of the pulse timing parameters may become invalid.

   In the internal program memory, the freerun pulse output is not available. Do *not* set the following command parameters.

   - STT command: *mode*=0
   - SPG command: *Pc*=0

7. For VMU differential voltage measurements:

   Select the measurement unit (VMU1 or VMU2) carefully. Differential voltage measurements use the measurement range defined for the specified measurement unit.

8. CL command:

   When executing a program from internal memory, the CL command disables the unit in the HIGH VOLTAGE state (forcing more than ±40 V, or the voltage compliance set to more than ±40 V). To prevent the unit output switch from electrical damage, enter the DV command to lower the output voltage to 0 V or less than 40 V, before the CL command.

9. DV command:

   When executing a program from internal memory, the DV command is available for the unit which is in the output disable state by the CL command. This may occur the over current on the SMU. Use the DV command for the unit in the output enable state by the CN command.

10. Interlock circuit:

    The internal memory program *cannot* be executed if the interlock circuit is open. To execute the internal memory program, close the interlock circuit.

A program example using the internal program memory is shown below. This program does the following:

- enters a high-speed spot measurement program in program memory 1.
- enters a pulsed spot measurement program in program memory 2.
- prints the internal memory program listing on the screen.
- executes the internal memory program 1 and 2.
- prints the measurement results on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Fmt,Source,Gate,Drain,Sub,Mem,Err
40      INTEGER Vrange,Arange,Irange
50      Fmt=1             !ASCII with header <LF^EOI>
60      Source=1          !SMU1
70      Drain=2           !SMU2
80      Gate=3            !SMU3
90      Sub=4             !SMU4
100     Vrange=12         !12:20 V Limited auto ranging
110     Arange=0          ! 0:Auto ranging
120     Irange=14         !14:1 uA Limited auto ranging
130     Vg=3              !Gate voltage (V)
140     Vd=5              !Drain voltage (V)
150     Vsub=0            !Substrate voltage (V)
160     Vs=0              !Source voltage (V)
170     Icomp=.1          !Current compliance (A)
180     Icomp_g=.01       !Current compliance for Gate (A)
190     Vg_b=0            !Gate pulse base voltage (V)
200     Hold=0            !Hold time of Gate pulse (sec)
210     Width=.1          !Pulse width of Gate pulse (sec)
220     Period=.2         !Pulse period of Gate pulse (sec)
230    !
240     OUTPUT @Hp415x;"US"
250     OUTPUT @Hp415x;"FMT ";Fmt
260    !
270     Mem=1             ! High-speed spot measurement
280     OUTPUT @Hp415x;"ST ";Mem
290     OUTPUT @Hp415x;"CN ";Gate,Drain,Source,Sub
300     OUTPUT @Hp415x;"DV ";Source,Arange,Vs,Icomp
310     OUTPUT @Hp415x;"DV ";Sub,Arange,Vsub,Icomp
320     OUTPUT @Hp415x;"DV ";Drain,Vrange,Vd,Icomp
330     OUTPUT @Hp415x;"DV ";Gate,Vrange,Vg,Icomp_g
340     OUTPUT @Hp415x;"TI ";Drain,Irange
350     OUTPUT @Hp415x;"CL"
360     OUTPUT @Hp415x;"END"
```

Line No.	Description
10	Assigns the I/O path to control the 4155C/4156C.
50 to 220	Sets the measurement parameters.
240	Enters the 4155C/4156C FLEX command control mode.
250	Specifies the data output format.
270 to 360	Stores the high-speed spot measurement program in the memory 1.

```
270    Mem=1            ! High-speed spot measurement
280    OUTPUT @Hp415x;"ST ";Mem
290    OUTPUT @Hp415x;"CN ";Gate,Drain,Source,Sub
300    OUTPUT @Hp415x;"DV ";Source,Arange,Vs,Icomp
310    OUTPUT @Hp415x;"DV ";Sub,Arange,Vsub,Icomp
320    OUTPUT @Hp415x;"DV ";Drain,Vrange,Vd,Icomp
330    OUTPUT @Hp415x;"DV ";Gate,Vrange,Vg,Icomp_g
340    OUTPUT @Hp415x;"TI ";Drain,Irange
350    OUTPUT @Hp415x;"CL"
360    OUTPUT @Hp415x;"END"
370    CALL Check_memory(Mem)
380   !
390    Mem=2            ! Pulsed spot measurement
400    OUTPUT @Hp415x;"ST ";Mem
410    OUTPUT @Hp415x;"CN ";Gate,Drain,Source,Sub
420    OUTPUT @Hp415x;"PT ";Hold,Width,Period
430    OUTPUT @Hp415x;"DV ";Source,Arange,Vs,Icomp
440    OUTPUT @Hp415x;"DV ";Sub,Arange,Vsub,Icomp
450    OUTPUT @Hp415x;"DV ";Drain,Vrange,Vd,Icomp
460    OUTPUT @Hp415x;"PV ";Gate,Vrange,Vg_b,Vg,Icomp
470    OUTPUT @Hp415x;"MM ";3,Drain
480    OUTPUT @Hp415x;"XE"
490    OUTPUT @Hp415x;"CL"
500    OUTPUT @Hp415x;"END"
510    CALL Check_memory(Mem)
520   !
530    OUTPUT @Hp415x;"DO 1,2"
540    OUTPUT @Hp415x;"RMD? 2"
550    ENTER @Hp415x USING "#,5X,13D,6X,13D,X";A,B
560    PRINT "High Speed Spot Id(A)=";A
570    PRINT "Pulsed Spot Id(A)=";B
580   !
590    OUTPUT @Hp415x;":PAGE"
600    END
610   !
620    SUB Check_memory(INTEGER Mem)
630      DIM Mem$[100]
640      ASSIGN @Hp415x TO 800
650      OUTPUT @Hp415x;"LST? ";Mem
660      LOOP
670        ENTER @Hp415x;Mem$
680        PRINT Mem$
690      EXIT IF Mem$="END"
700      END LOOP
710    SUBEND
```

Line No.	Description
270 to 360	Stores the high-speed spot measurement program in the memory 1.
390 to 500	Stores the 1 ch pulsed spot measurement program in the memory 2.
530	Executes the internal program memory.
540 to 570	Reads the measurement result and prints the data on the screen.
590	Returns to the 4155C/4156C default control mode (SCPI mode).
620 to 710	Reads the internal memory program and prints the program listing.

Using Enhanced Sweep Stop Function

The following example program uses the ESC command which defines the enhanced stop condition and enables the function. The program executes a MOSFET threshold voltage measurement, and displays the measurement result data on the screen. If the stop condition is true during the measurement, the sweep stops and the data status on the screen displays an “E” (sweep stopped). This function is available only for the sweep measurement.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Gate,Source,Drain,Sub
40      INTEGER V_n,Rm,Ro,Swp,Var1,Nub
50      REAL Vg(101)
60      Source=1        ! 1: SMU1
70      Drain=2         ! 2: SMU2
80      Gate=3          ! 3: SMU3
90      Sub=4           ! 4: SMU4
100     V_b=0           ! Sweep start voltage (V)
110     V_e=3           ! Sweep stop voltage (V)
120     V_n=101         ! Number of sweep steps
130     G_comp=.01      ! Current compliance (A) for Gate
140     D_comp=.1       ! Current compliance (A) for Drain
150     Rm=13           ! 13: 100 nA limited auto ranging
160     Ro=0            ! 0: Auto ranging
170     Swp=1           ! Linear single sweep
180     Ta=.1           ! Tgt of [D(N+1)-D(N)]/D(N) value
190     Tb=5.E-7        ! Tgt of measured value
200    !
210     OUTPUT @Hp415x;"US"
220     OUTPUT @Hp415x;"FMT 1,1"  !ASCII w/source data
230     OUTPUT @Hp415x;"MM 2,";Drain  !Sweep measurement
```

Line Number	Description
10	Assigns the I/O path for controlling the 4155C/4156C.
60 to 190	Sets the measurement parameters.
210	Enters the 4155C/4156C FLEX command control mode.
220	Specifies the data output format.
230	Sets the sweep measurement mode and its measurement channel.

```
240    OUTPUT @Hp415x;"ESC ";1,Drain,2,Ta,2,Tb
250    OUTPUT @Hp415x;"RI ";Drain,Rm
260    OUTPUT @Hp415x;"CN ";Source,Sub,Gate,Drain
270    OUTPUT @Hp415x;"DV ";Source,Ro,0,.1
280    OUTPUT @Hp415x;"DV ";Sub,Ro,0,.1
290    OUTPUT @Hp415x;"WV ";Drain,Swp,Ro,V_b,V_e,V_n,D_comp
300    OUTPUT @Hp415x;"WSV ";Gate,Ro,V_b,V_e,G_comp
310    OUTPUT @Hp415x;"XE"
320    OUTPUT @Hp415x;"*OPC?"
330    ENTER @Hp415x;C
340    OUTPUT @Hp415x;"CL"
350   !
360    OUTPUT @Hp415x;":SYST:ERR?"
370    ENTER @Hp415x;C,C$
380    IF C=0 THEN
390      GOTO 450
400    ELSE
410      PRINT C,C$
420      GOTO 570
430    END IF
440   !
450    OUTPUT @Hp415x;"NUB?"
460    ENTER @Hp415x;Nub
470    IF Nub=0 OR Nub<>INT(Nub/2)*2 THEN
480      DISP Nub;"data returned. No. of data must be N*2."
490      GOTO 570
500    ELSE
510      FOR Var1=1 TO Nub/2
520        OUTPUT @Hp415x;"RMD? 2"
530        ENTER @Hp415x USING "#,5X,13D,X,3A,2X,13D,X";A,St$,B
540        PRINT St$;Var1;"Vg=";B;"V, Id=";A*1.E+6;"uA"
550      NEXT Var1
560    END IF
570    OUTPUT @Hp415x;":PAGE"
580    END
```

Line Number	Description
240	Sets the stop condition. The sweep stops if the ratio of changing data is Ta or greater, and the measured data is Tb or greater.
250 to 340	Executes a sweep measurement.
360 to 430	Checks for errors.
450 to 560	Reads the measurement data and displays the data on the screen.
570	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

Reading Time Stamp Data

The 4155C/4156C returns a time stamp with the measurement data in all measurement modes. Enter the MM command to define the measurement mode and enter the TSC command to set the time stamp output ON.

Function	FLEX Command	Parameters
Controls tthe ime stamp output	TSC	*onoff*
Resets the time stamp	TSR	
Returns the time data since TSR	TSQ?	

The following commands returns the time stamp regardless of the TSC command setting. You can use the commands regardless of the MM command settings.

Function	FLEX Command	Parameters
Forces a constant voltage	TDV	*chnum,range,output*[,*Icomp*]
Forces a constant current	TDI	*chnum,range,output*[,*Vcomp*]
Measures the current	TTI	*chnum,range*
Measures the voltage	TTV	*chnum,range*
Measures the current and reads the data	TTI?	*chnum,range*
Measures the voltage and reads the data	TTV?	*chnum,range*

The TTI/TTV/TTI?/TTV? commands are for high-speed spot measurements. The query executes the measurement and reads the data. When using the TTI/TTV commands use the RMD? command to read the data.

You *cannot* use both the TI/TV/TTI/TTV commands and the TI?/TV?/TTI?/TTV? commands in the same measurement program. The TI/TV/TI?/TV? commands execute high-speed spot measurements without the time stamp.

The time stamp function does not support QSCV and search measurements.

The following example program executes a high-speed spot measurement using the TTI? command, and displays the measurement result and time stamp on the screen.

```
10      ASSIGN @Hp415x TO 800
20    !
30      INTEGER Source,Drain,Gate,Sub
40      INTEGER Range_s,Range_g,Range_d,Range_i,B,C
50      DIM B$[100]
60    !
70      Source=1        !1:SMU1
80      Drain=2         !2:SMU2
90      Gate=3          !3:SMU3
100     Sub=4           !4:SMU4
110     Range_s=11      !11: 2 V Limited Auto Ranging
120     Range_g=12      !12:20 V Limited Auto Ranging
130     Range_d=12      !12:20 V Limited Auto Ranging
140     Range_i=15      !15:10 uA Limited Auto Ranging
150     Vs=0            ! Source Voltage
160     Vd=5            ! Drain Voltage
170     Vg=3            ! Gate Voltage
180     Vsub=0          ! Substrate Voltage
190     Icomp_g=.01     ! Current compliance for gate
200     Icomp=.1        ! Current compliance
210   !
220     OUTPUT @Hp415x;"US"
230     OUTPUT @Hp415x;"FMT 1"         !ASCII w/header
240     OUTPUT @Hp415x;"AV 1"          !Number of average
250     OUTPUT @Hp415x;"SIT 1,.0005"   !Integ for Short
260     OUTPUT @Hp415x;"SIT 3,.04"     !Integ for Long
270     OUTPUT @Hp415x;"SLI 1"         !Short:1,Long:3
280     OUTPUT @Hp415x;"FL 1"          !Filter on:1, off:0
290     OUTPUT @Hp415x;"CN ";Source,Drain,Gate,Sub
300     OUTPUT @Hp415x;"TSR"
```

Line Number	Description
10	Assigns the I/O path for controlling the 4155C/4156C.
70 to 200	Sets the measurement parameters.
220	Enters the 4155C/4156C FLEX command control mode.
230	Specifies the data output format.
240 to 270	Sets the integration time.
280	Sets the filter mode.
290	Enables the measurement units.
300	Resets the time stamp (sets the time stamp to 0 sec).

```
310    OUTPUT @Hp415x;"DV ";Source,Range_s,Vs,Icomp
320    OUTPUT @Hp415x;"DV ";Sub,Range_s,Vsub,Icomp
330    OUTPUT @Hp415x;"DV ";Gate,Range_g,Vg,Icomp_g
340    OUTPUT @Hp415x;"DV ";Drain,Range_d,Vd,Icomp
350  !
360    OUTPUT @Hp415x;"*OPC?"
370    ENTER @Hp415x;C
380  !
390    OUTPUT @Hp415x;":SYST:ERR?"
400    ENTER @Hp415x;B,B$
410    IF B=0 THEN
420      OUTPUT @Hp415x;"TSQ?"
430      ENTER @Hp415x USING "#,5X,13D,X";T1
440      OUTPUT @Hp415x;"TTI? ";Drain,Range_i
450      ENTER @Hp415x USING "#,5X,13D,6X,13D,X";T2,Md1
460      PRINT "Id=";Md1*1000;"mA"
470      PRINT "Measurement time=";(T2-T1)*.1;"ms"
480    ELSE
490      PRINT "ERROR:";B$
500    END IF
510  !
520    OUTPUT @Hp415x;"CL"
530    OUTPUT @Hp415x;"TSQ?"
540    ENTER @Hp415x USING "#,5X,13D,X";T3
550    PRINT "Source output time=";T3*.1;"ms"
560    OUTPUT @Hp415x;":PAGE"
570    END
```

Line Number	Description
310 to 340	Forces the dc voltage.
390 to 400	Checks for errors.
420 to 430	Reads the time stamp data before starting the measurement.
440 to 470	Executes a high-speed spot measurement, and displays the measured data and the time stamp on the screen.
490	Prints an error code if an error has occurred.
520	Disables the measurement units.
530 to 550	Reads the time stamp data after stopping the source output, and displays the source output time.
560	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

The following example program executes the sampling measurement, and displays the measurement result and time data on the screen.

```
10      ASSIGN @Hp415x TO 800
20    !
30      INTEGER High,Low,Range_v,Range_i
40      INTEGER Point,Abort,A,C,I
50      REAL B,R
60      DIM C$[50]
70      High=1          !1:SMU1
80      Low=2           !2:SMU2
90      Hold=.1         !Hold time (sec)
100     Interval=.01    !Sampling interval (sec)
110     Point=9         !Number of sampling points
120     Abort=2         !2: Selects all abort condition
130     Range_v=0       !0: Auto range
140     Vbase=0         !Base voltage for High
150     Vbias=.05       !Bias voltage for High
160     Icomp=.1        !Current compliance
170     Vl=0            !Voltage for Low
180     Range_i=-19     !-19: 100 mA fixed range
190   !
200     OUTPUT @Hp415x;"US"
210     OUTPUT @Hp415x;"FMT 1,1"      ! ASCII w/header,index
220     OUTPUT @Hp415x;"TSC 1"        ! Time stamp
230     OUTPUT @Hp415x;"CN ";High,Low
240     OUTPUT @Hp415x;"MCC"
250     OUTPUT @Hp415x;"MT ";Hold,Interval,Point
260     OUTPUT @Hp415x;"MM 10,";High ! Sampling measurement
270     OUTPUT @Hp415x;"RI ";High,Range_i
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
70 to 180	Sets the measurement parameters.
200	Enters the 4155C/4156C FLEX command control mode.
210	Specifies the data output format.
220	Enables the time stamp output.
230	Enables the measurement units.
240 to 270	Sets the sampling measurement conditions.

```
280    OUTPUT @Hp415x;"MSC ";Abort
290    OUTPUT @Hp415x;"MV ";High,Range_v,Vbase,Vbias,Icomp
300    OUTPUT @Hp415x;"DV ";Low,Range_v,Vl,Icomp
310  !
320    OUTPUT @Hp415x;"TSR"
330    OUTPUT @Hp415x;"XE"
340    OUTPUT @Hp415x;"*OPC?"
350    ENTER @Hp415x;C
360    OUTPUT @Hp415x;"CL"
370   !
380    OUTPUT @Hp415x;":SYST:ERR?"
390    ENTER @Hp415x;C,C$
400   !
410    IF C=0 THEN
420      PRINT "Hold time=";Hold*1000;"ms"
430      PRINT "Sampling interval=";Interval*1000;"ms"
440      FOR I=1 TO Point
450        OUTPUT @Hp415x;"RMD? 3"
460        ENTER @Hp415x USING "#,5X,13D,6X,13D,6X,13D,X";A,T1,B
470        R=Vbias/B
480        PRINT "No.";A;" R=";R;"ohm, Time=";T1*.1;"ms"
490      NEXT I
500    ELSE
510      PRINT "ERROR:";C$
520    END IF
530  !
540    OUTPUT @Hp415x;":PAGE"
550    END
```

Line Number	Description
280	Sets the sampling stop condition.
290 to 300	Forces the sampling source to the high terminal, and the dc voltage to the low terminal.
320 to 360	Resets the time stamp, and executes a sampling measurement.
380 to 390	Checks for errors.
420 to 490	Reads the measurement data and displays the data on the screen.
510	Prints an error code if an error has occurred.
540	Returns the 4155C/4156C to the default control mode (SCPI command control mode).

Reading and Writing Data to a File

To read or write ASCII data to a file, use the following commands.

Function	FLEX Command	Parameters
Selects the mass storage device	SDSK	0, 1, 2, 3, or 4.
Opens the specified file	OPEN	*file_name,mode*
Closes the file	CLOSE	
Writes data	WR	*data* (ASCII data, 254 bytes maximum)
Reads data	RD?	a maximum of 8 KB of ASCII data can be read

To read or write file data on the network file system, the SYSTEM: MISCELLANEOUS tables below must be defined, and the 4155C/4156C must be connected to your LAN.

- 4155C/4156C NETWORK SETUP table
- NETWORK DRIVE SETUP table

The following example writes the data (Data$) to a file (MDATA) on the network file system, defined in the NETWORK DRIVE SETUP table. Data$ must *not* include a single quotation (').

```
100  OUTPUT @Hp415x;"SDSK 1"           !1:NFS1
110  OUTPUT @Hp415x;"OPEN 'MDATA',1"   !1:Over write mode
120  OUTPUT @Hp415x;"WR ";CHR$(39)&Data$&CHR$(39)
130  OUTPUT @Hp415x;"CLOSE"
```

The following example reads the data from a file (MDATA) on a diskette, and enters the data into Data$.

```
100  OUTPUT @Hp415x;"SDSK 0"           !0:diskette
110  OUTPUT @Hp415x;"OPEN 'MDATA',0"   !0:Read only mode
120  OUTPUT @Hp415x;"RD?"
130  ENTER @Hp415x;Data$
140  OUTPUT @Hp415x;"CLOSE"
```

Example 1

The following program example:

1. Executes high-speed spot measurements.
2. Writes the measurement data with a separator (, :comma) into a file on the diskette.
3. Reads the data from the file on the diskette.
4. Prints the data on the screen.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30     !
40      DIM A$[255]
50      DIM Mdata$[8200]
60      REAL Vout,Mdata
70      INTEGER I,M,N,X,Y
80     !
90      File$="MDATA"
100     Fmt=1
110     Disk=0
120    !
130     OUTPUT @Hp415x;"US"
140     OUTPUT @Hp415x;"FMT ";Fmt
150    !**** HIGH-SPEED SPOT MEASUREMENTS ****
160     OUTPUT @Hp415x;"CN 1"
170     X=1
180     FOR I=1 TO 11
190       Vout=(I-1)*.5
200       OUTPUT @Hp415x;"DV 1,12,";Vout
210       OUTPUT @Hp415x;"TI? 1,15"
220       ENTER @Hp415x USING "#,5X,13D,X";Mdata
230       IF I=11 THEN
240         Mdata$[X,X+13]=VAL$(Mdata)
250         GOTO 310
260       ELSE
270         Mdata$[X,X+13]=VAL$(Mdata)&CHR$(44)
280       END IF
290       X=X+14
300     NEXT I
```

Line No.	Description
10	Assigns the I/O path to control the 4155C/4156C.
130	Enters the 4155C/4156C FLEX command control mode.
140	Specifies the data output format.
160	Enables the measurement unit.
180 to 300	Forces the dc voltage, and measures the dc current. Measured data is entered into Mdata$ with a data separator (,).

```
310    OUTPUT @Hp415x;"CL"
320   !
330   !**** WRITES MEASUREMENT DATA ****
340    N=LEN(Mdata$)
350    M=INT(N/250)+1
360    OUTPUT @Hp415x;"SDSK 0"
370    OUTPUT @Hp415x;"OPEN ";CHR$(39)&File$&CHR$(39);",1"
380    Y=1
390    FOR I=1 TO M
400      A$=Mdata$[Y,Y+249]
410      OUTPUT @Hp415x;"WR ";CHR$(39)&A$&CHR$(39)
420      WAIT .1
430      Y=Y+250
440    NEXT I
450    OUTPUT @Hp415x;"CLOSE"
460   !**** READS MEASUREMENT DATA ****
470    OUTPUT @Hp415x;"OPEN ";CHR$(39)&File$&CHR$(39);",0"
480    OUTPUT @Hp415x;"RD?"
490    ENTER @Hp415x;Mdata$
500    OUTPUT @Hp415x;"CLOSE"
510   !**** PRINTS MEASUREMENT DATA ****
520    PRINT Mdata$
530   !
540    OUTPUT @Hp415x;":PAGE"
550    END
```

Line No.	Description
310	Disables the measurement unit.
360	Sets the mass storage device.
370	Opens the specified file (file name: MDATA).
390 to 440	Writes the measurement data (Mdata$) to MDATA.
450	Closes the file.
460 to 500	Reads the measurement data from MDATA.
520	Prints the measurement data on the screen.
540	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Example 2

The following program example:

1. executes staircase sweep measurements.
2. writes the measurement data with a separator (, :comma) to a file on the diskette.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      INTEGER Fmt,Emitter,Base,Collector,Mmode,Swp,N
40      INTEGER Mrange,Ib_point,Range,Var1,Var2
50      REAL Vc(101)
60      DIM Mdata$[11000]
70      DIM C$[250]
80      Fmt=1           ! 1: ASCII with header <LF^EOI>
90      Emitter=1       ! 1: SMU1
100     Base=2          ! 2: SMU2
110     Collector=3     ! 3: SMU3
120     Swp=1           ! 1: Linear single sweep mode
130     V1=0            ! Collector voltage start value (V)
140     V2=1            ! Collector voltage stop value (V)
150     N=101           ! Collector voltage number of steps
160     Comp=.1         ! Current compliance (A) for collector
170     Mrange=14       ! 14: 1 uA limited auto ranging
180     Range=0         ! 0: Auto ranging
190     Ve=0            ! Emitter voltage (V)
200     Ie_comp=.1      ! Current compliance (A) for emitter
210     Mmode=2         ! 2: Staircase sweep measurement
220     Ib_start=1.E-5  ! Ib start value (A)
230     Ib_step=1.E-5   ! Ib step value (A)
240     Ib_point=3      ! Number of Ib steps
250     Vb_comp=2       ! Voltage compliance (V) for base
260     X=1             ! Mdata$ INDEX
270     Disk=0          ! 0:diskette
280     File$="DATA1"   ! File name for measurement data
290    !
300     OUTPUT @Hp415x;"US"
310     OUTPUT @Hp415x;"FMT ";Fmt
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
80 to 280	Sets the measurement parameters.
300	Enters the 4155C/4156C FLEX command control mode.
310	Specifies the data output format.

```
320   !
330    Vc_step=(V2-V1)/(N-1)
340    FOR Var1=1 TO N
350      Vc(Var1)=V1+(Var1-1)*Vc_step
360    NEXT Var1
370    OUTPUT @Hp415x;"CN ";Emitter,Base,Collector
380    OUTPUT @Hp415x;"WV ";Collector,Swp,Range,V1,V2,N,Comp
390    OUTPUT @Hp415x;"RI ";Collector,Mrange
400    OUTPUT @Hp415x;"DV ";Emitter,Range,Ve,Ie_comp
410    OUTPUT @Hp415x;"MM ";Mmode,Collector
420    FOR Var2=1 TO Ib_point
430      Ib=Ib_start+(Var2-1)*Ib_step
440      OUTPUT @Hp415x;"DI ";Base,Range,Ib,Vb_comp
450      OUTPUT @Hp415x;"XE"
460     !
470      OUTPUT @Hp415x;":SYST:ERR?"
480      ENTER @Hp415x;C,C$
490      IF C=0 THEN
500        GOTO 560
510      ELSE
520        PRINT C,C$
530        GOTO 790
540      END IF
550     !
```

Line Number	Description
330 to 360	Calculates the collector voltage values.
370	Enables the measurement units.
380	Sets the staircase sweep source (Vc).
390	Sets the measurement range (Ic).
400	Forces the dc voltage (Ve).
410	Sets the measurement mode.
440	Forces the dc current (Ib).
450	Executes a staircase sweep measurement.
470 to 540	Checks for errors.

```
560       FOR Var1=1 TO N
570         OUTPUT @Hp415x;"RMD? 1"
580         ENTER @Hp415x USING "#,5X,13D,X";Ic
590         Mdata$[X,X+9]=VAL$(Ib)&CHR$(44)
600         Mdata$[X+10,X+19]=VAL$(Vc(Var1))&CHR$(44)
610         Mdata$[X+20,X+34]=VAL$(Ic)&CHR$(13)&CHR$(10)
620         X=X+35
630       NEXT Var1
640     NEXT Var2
650    !
660     OUTPUT @Hp415x;"SDSK ";Disk
670     OUTPUT @Hp415x;"OPEN ";CHR$(39)&File$&CHR$(39);",1"
680     C$="Ib(A),Vc(V),Ic(A)"&CHR$(13)&CHR$(10)
690     OUTPUT @Hp415x;"WR ";CHR$(39)&C$&CHR$(39)
700     N=LEN(Mdata$)
710     M=INT(N/250)+1
720     X=1
730     FOR I=1 TO M
740       C$=Mdata$[X,X+249]
750       OUTPUT @Hp415x;"WR ";CHR$(39)&C$&CHR$(39)
760       X=X+250
770     NEXT I
780     OUTPUT @Hp415x;"CLOSE"
790     OUTPUT @Hp415x;"CL"
800     OUTPUT @Hp415x;":PAGE"
810     END
```

Line Number	Description
560 to 630	Reads the measurement data.
660	Specifies the mass storage device.
670	Opens the data file (DATA1) to store the measurement data.
680 to 690	Writes "Ib(A),Vc(V),Ic(A)" (with a return and line feed) into DATA1.
700 to 770	Writes measured data (with a return and line feed) into DATA1.
780	Closes the file (DATA1).
790	Disables the measurement units.
800	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Example 3

The following program example does following a or b:

a. Reads the data from a specified file on the diskette, and writes the data to a specified file on the network file system.

b. Reads the data from a specified file on the network file system, and writes the data to a specified file on the diskette.

Program example limitations:

- The mass storage devices are the disk drive and the network file system, which is first defined in the NETWORK DRIVE SETUP table.
- The data must be a maximum of 8 KB.
- A single quotation (') must *not* be included in the data.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      DIM A$[255]
40      DIM B$[8200]
50      DIM C$[100]
60      INTEGER Source,Dest
70      CLEAR SCREEN
80     !
90      PRINT "********************************"
100     PRINT "* Select Source."
110     PRINT "* Enter 1 (NFS1) or 0 (diskette)"
120     INPUT Source
130     IF Source=1 THEN
140       PRINT "* NFS1 ----> DISKETTE"
150       Dest=0
160     ELSE
170       IF Source=0 THEN
180         PRINT "* DISKETTE ----> NFS1"
190         Dest=1
200       ELSE
210         PRINT "* Source selection error. END."
220         GOTO 630
230       END IF
240     END IF
250     PRINT "********************************"
260     PRINT "* Enter READ file name."
270     INPUT Rname$
280     PRINT "* READ file = ";Rname$
290     PRINT "********************************"
300     PRINT "* Enter WRITE file name."
310     INPUT Wname$
320     PRINT "* WRITE file = ";Wname$
330     PRINT "********************************"
340    !
350     OUTPUT @Hp415x;"US"
360     OUTPUT @Hp415x;"SDSK ";Source
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
90 to 250	Waits for the source device input (0: diskette, 1: NFS1) and stores the value.
260 to 290	Waits for the file name to be read and stores the value.
300 to 330	Waits for the file name to be written and stores the value.
350	Enters the 4155C/4156C FLEX command control mode.
360	Sets the "source" mass storage device.

```
370    OUTPUT @Hp415x;"OPEN ";CHR$(39)&Rname$&CHR$(39);",0"
380    OUTPUT @Hp415x;"RD?"
390    ENTER @Hp415x USING "-K";B$
400    OUTPUT @Hp415x;"CLOSE"
410    OUTPUT @Hp415x;"SDSK ";Dest
420    OUTPUT @Hp415x;"OPEN ";CHR$(39)&Wname$&CHR$(39);",1"
430    N=LEN(B$)
440    M=INT(N/250)+1
450    X=1
460    FOR I=1 TO M
470      A$=B$[X,X+249]
480      X=X+250
490      OUTPUT @Hp415x;"WR ";CHR$(39)&A$&CHR$(39)
500      WAIT .1
510    NEXT I
520    OUTPUT @Hp415x;"CLOSE"
530   !
540    OUTPUT @Hp415x;":SYST:ERR?"
550    ENTER @Hp415x;C,C$
560    IF C=0 THEN
570      PRINT "* File transfer was completed."
580      GOTO 630
590    ELSE
600      PRINT "* Code=";C
610      PRINT "* Message =";C$
620    END IF
630    PRINT "********************************"
640    OUTPUT @Hp415x;":PAGE"
650    END
```

Line Number	Description
370	Opens the file to read data.
380 to 390	Reads the data (8 KB maximum) from MDATA.
400	Closes the file.
410	Sets the "destination" mass storage device.
420	Opens the file to write data.
430 to 510	Writes the data to MDATA.
520	Closes the file.
540 to 630	Checks for errors.
640	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Printing Data

To print data to a remote printer connected to the print server, use the following commands.

Function	FLEX Command	Parameters
Specifies network drive	SDSK	1, 2, 3, or 4.
Specifies remote printer	SPR	1, 2, 3, or 4.
Spools data	SPL	*data* (ASCII data)
Executes print-out	PRN	

The 4155C/4156C must be connected to your LAN, and the following setup tables on the SYSTEM: MISCELLANEOUS screen must be defined.

- 4155C/4156C NETWORK SETUP table
- NETWORK PRINTER SETUP table
- NETWORK DRIVE SETUP table

The following example executes the data print-out (Data$) using the remote printer (Printer1), defined in the NETWORK PRINTER SETUP table. Data$ must *not* include a single quotation (').

```
100  Disk=1    !1:NFS1, 2:NFS2, 3:NFS3, 4:NFS4
110  Printer=1 !1:Printer1, 2:Printer2, 3:Printer3, 4:Printer4
120 !
130  OUTPUT @Hp415x;"SDSK ";Disk
140  OUTPUT @Hp415x;"SPR ";Printer
150  OUTPUT @Hp415x;"SPL ";CHR$(39)&Data$&CHR$(39)
160  OUTPUT @Hp415x;"PRN"
```

The following program example:

1. executes high-speed spot measurements.
2. prints the data to the remote printer.

```
10      ASSIGN @Hp415x TO 800
20      OPTION BASE 1
30      DIM A$[25]
40      DIM C$[50]
50      DIM Mdata$[8200]
60      REAL Vout,Mdata
70      INTEGER I,N,X,Y,Fmt,Disk,Prn,No_test
80     !
90      Fmt=1        !1: ASCII with header <LF^EOI>
100     Disk=1       !1: NFS1
110     Prn=1        !1: Remote printer 1
120     No_test=10   ! Number of measurement points
130    !
140     OUTPUT @Hp415x;"US"
150     OUTPUT @Hp415x;"FMT ";Fmt
160    !
170    !HIGH-SPEED SPOT MEASUREMENTS ****************
180     OUTPUT @Hp415x;"CN 1"
190     X=1
200     FOR I=1 TO No_test
210       Vout=(I-1)*.5
220       OUTPUT @Hp415x;"DV 1,12,";Vout
230       OUTPUT @Hp415x;"TI? 1,15"
240       ENTER @Hp415x USING "#,5X,13D,X";Mdata
250       Mdata$[X,X+12]=VAL$(Mdata)
260       X=X+13
270     NEXT I
```

Line Number	Description
10	Assigns the I/O path to control the 4155C/4156C.
140	Enters the 4155C/4156C FLEX command control mode.
150	Specifies the data output format.
180	Enables the measurement unit.
200 to 270	Forces the dc voltage (0 to 5 V, in 0.5 V steps) and measures the dc current. Measured data is entered into Mdata$.

```
280    OUTPUT @Hp415x;"CL"
290   !
300   !PRINTS MEASUREMENT DATA ********************
310    OUTPUT @Hp415x;"SDSK ";Disk
320    OUTPUT @Hp415x;"SPR ";Prn
330   !
340    Y=1
350    FOR I=1 TO No_test
360      A$="I("&VAL$(I)&")="&Mdata$[Y,Y+12]
370      A$=A$&CHR$(13)&CHR$(10)
380      OUTPUT @Hp415x;"SPL ";CHR$(39)&A$&CHR$(39)
390      Y=Y+13
400    NEXT I
410   !
420    OUTPUT @Hp415x;":SYST:ERR?"
430    ENTER @Hp415x;C,C$
440    IF C=0 THEN
450      OUTPUT @Hp415x;"PRN"
460    ELSE
470      PRINT "ERROR:";C$
480    END IF
490    OUTPUT @Hp415x;":PAGE"
500    END
```

Line Number	Description
280	Disables the measurement unit.
310	Sets the mass storage device.
320	Specifies the remote printer.
350 to 400	Spools the measurement data.
420 to 430	Checks for errors.
450	Requests a print-out to the remote printer.
470	If an error has occurred, prints the error message on the screen.
490	Returns to the 4155C/4156C default control mode (SCPI command control mode).

Reading Binary Output Data

The program examples shown in the previous sections use the ASCII data output format for measurement data.

ASCII data format is easier than binary data format for reading the measurement data, because ASCII data can be read directly, without rearranging the data. The data length is longer in ASCII format than in binary data format, so the data transfer time in ASCII format is longer than in binary format.

To reduce the data transfer time, use binary data output format.

For details of data output formats, refer to Chapter 1 of the *GPIB Command Reference*.

The following program example:

1. executes high-speed spot measurements
2. reads the measurement data using binary output format
3. rearranges the data and calculates the measured data
4. prints the measured data on the screen

```
10      ASSIGN @Hp415x TO 800
20    !
30      INTEGER Fmt,Average,Type,Source,Drain,Gate,Sub
40      INTEGER Range_2v,Range_20v,Range_i,B,C
50      REAL Value,Status
60      DIM Mdata$[6]
70      DIM B$[50]
80    !
90      Fmt=3           !3:Binary <LF^EOI>
100     Average=1       !Number of averaging
110     Sinteg=.0005    !Integ Time of Short
120     Linteg=.04      !Integ Time of Long
130     Type=1          !1:Short, 2:Medium, 3:Long
140     Filter=0        !0:Filter off, 1:Filter on
150     Source=1        !1:SMU1
160     Drain=2         !2:SMU2
170     Gate=3          !3:SMU3
180     Sub=4           !4:SMU4
190     Range_2v=11     !11: 2 V Limited Auto Ranging
200     Range_20v=12    !12:20 V Limited Auto Ranging
210     Range_i=15      !15:10 uA Limited Auto Ranging
220     Vs=0            ! Source Voltage
230     Vd=5            ! Drain Voltage
240     Vg=3            ! Gate Voltage
250     Vsub=0          ! Substrate Voltage
260     Icomp_g=.01     ! Current compliance for gate
```

```
270    Icomp=.1       ! Current compliance
280  !
290    OUTPUT @Hp415x;"US"
300    OUTPUT @Hp415x;"FMT ";Fmt
310    OUTPUT @Hp415x;"AV ";Average
320    OUTPUT @Hp415x;"SIT 1,";Sinteg  !for Short
330    OUTPUT @Hp415x;"SIT 3,";Linteg  !for Long
340    OUTPUT @Hp415x;"SLI ";Type
350    OUTPUT @Hp415x;"FL ";Filter
360    OUTPUT @Hp415x;"CN ";Source,Drain,Gate,Sub
370    OUTPUT @Hp415x;"DV ";Source,Range_2v,Vs,Icomp
380    OUTPUT @Hp415x;"DV ";Sub,Range_2v,Vsub,Icomp
390    OUTPUT @Hp415x;"DV ";Gate,Range_20v,Vg,Icomp_g
400    OUTPUT @Hp415x;"DV ";Drain,Range_20v,Vd,Icomp
410  !
420    OUTPUT @Hp415x;":SYST:ERR?"
430    ENTER @Hp415x;B,B$
440    IF B=0 THEN
450      OUTPUT @Hp415x;"TI? ";Drain,Range_i
460      OUTPUT @Hp415x;"CL"
470      ENTER @Hp415x USING "#,6A";Mdata$
480    ELSE
490      OUTPUT @Hp415x;"CL"
500      PRINT "ERROR=";B$
510      GOTO 570
520    END IF
530   !
540    CALL Get_data(Mdata$,Value,Status)
550    PRINT "Id(A)=";Value
560   !
```

Line No.	Description
10	Assigns the I/O path to control the 4155C/4156C.
90 to 270	Sets the measurement parameters.
290 to 400	Sets the measurement condition.
420 to 430	Checks for errors.
450 to 470	If no error has occurred, executes the high-speed spot measurement, disables the measurement unit, and reads the output data.
490 to 510	If an error has occurred, disables the measurement unit, prints the error message on the screen, and ends the program execution.
540	Calls the Get_data sub-program.
550	Prints the measured data on the screen.

```
570    OUTPUT @Hp415x;":PAGE"
580    END
590   !
600    SUB Get_data(Mdata$,Value,Status)
610      INTEGER D1,D2,D3,D4,D5,D6,M_s,I_v,X
620   !
630      D1=NUM(Mdata$[1;1])    !Byte 1
640      D2=NUM(Mdata$[2;1])    !Byte 2
650      D3=NUM(Mdata$[3;1])    !Byte 3
660      D4=NUM(Mdata$[4;1])    !Byte 4
670      D5=NUM(Mdata$[5;1])    !Byte 5
680      D6=NUM(Mdata$[6;1])    !Byte 6
690   !
700      M_s=BIT(D1,7)
710   !  M_s : 0: Source data, 1: Measurement data
720   !
730      I_v=SHIFT(BINAND(D1,112),4)  ! 112: 01110000
740   !  I_v :  0:V, 1:I, 6:Sampling index, 7:Status
750   !
760      Range_no=BINAND(D1,15)*2+BIT(D2,7)
770   !  15: 00001111
780   !
790      Status=BINAND(D5,31)*8+SHIFT(D6,5)
800   !
810      Count=SHIFT(D5,5)
820      Count=Count+D4*8
830      Count=Count+D3*8*256.
840      Count=Count+BINAND(D2,63)*8*256.*256.
850   !
860      IF BIT(D2,6)=0 THEN    ! Positive data
870        Count=Count
880      ELSE                   ! Negative data
890        Count=Count-33554432 ! 33554432=2^25
900      END IF
```

Line No.	Description
570	Returns to the 4155C/4156C default control mode (SCPI mode).
630 to 680	Separates 6 bytes of output data (Mdata$) to a byte (D1 to D6).
700	Reads the measurement or source data type.
730	Reads the data type (voltage, current, sampling index, or status information).
760	Reads the measurement range. This value is the reference ID of the measurement range.
790	Reads the status information.
810 to 900	Reads the Count value used to calculate the measurement data.

```
910   !
920      SELECT I_v
930      CASE 0                    ! V range
940        SELECT Range_no
950        CASE 10
960          Range=.2
970        CASE 11
980          Range=2
990        CASE 12
1000         Range=20
1010       CASE 13
1020         Range=40
1030       CASE 14
1040         Range=100
1050       CASE 15
1060         Range=200
1070       END SELECT
1080     CASE 1                     ! I range
1090       Range=10^(Range_no-20)
1100     CASE 6                     ! Sampling index
1110       Value=Count
1120       GOTO 1250
1130     CASE 7                     ! Status info
1140       Value=0
1150       GOTO 1250
1160     END SELECT
1170  !
1180     SELECT M_s
1190     CASE 0
1200       Value=Count*Range/20000
1210     CASE 1
1220       Value=Count*Range/1.E+6
1230     END SELECT
1240  !
1250   SUBEND
```

Line No.	Description
930 to 1090	For measurement data, finds the measurement range from the ID read by line 760.
1100 to 1120	For sampling index, enters the sampling index into the Value parameter and returns to the main program.
1130 to 1150	For status information, enters 0 into the Value parameter and returns to the main program. Only the Status parameter is effected.
1180 to 1230	Calculates the measurement or source data.

Using the US42 Control Mode

The 4155C/4156C FLEX command set includes some commands which have the same name as the GPIB commands for Agilent 4142B DC source/monitor. The US42 command provides an 4142B-like response for the following items:

- output data format
- query response
- status code (status byte)

To create a measurement program to control the 4155C/4156C, by modifying the program created to control the 4142B:

1. Change the GPIB address, if necessary.
2. Enter the US42 command to enter the FLEX command control mode.
3. Enter the ACH command to translate the measurement unit numbers.
4. Enter a space between the command and the first parameter.
5. If you do *not* specify the US42 command *level* parameter 16, enter the RMD? command to read the output data (before executing the ENTER command).
6. Enter the :PAGE command to return to the 4155C/4156C default control mode (SCPI command control mode).

The following program examples show a modified measurement program, which performs a high-speed spot measurement.

The original 4142B program:

```
10      ASSIGN @Hp4142 TO 717
20      INTEGER G_ch,D_ch,S_ch
30    !
40    !         !Source:    GNDU
50      G_ch=2  !Gate:      HPSMU (SLOT2)
60      D_ch=3  !Drain:     MPSMU (SLOT3)
70      S_ch=4  !Substrate: MPSMU (SLOT4)
80    !
90      OUTPUT @Hp4142;"FMT1"
100     OUTPUT @Hp4142;"CN";D_ch,G_ch,S_ch
110     OUTPUT @Hp4142;"DV";S_ch;",0,0,.1"
120     OUTPUT @Hp4142;"DV";G_ch;",0,3,.01"
130     OUTPUT @Hp4142;"DV";D_ch;",0,5,.1"
140     OUTPUT @Hp4142;"TI";D_ch;",0"
150     OUTPUT @Hp4142;"CL"
160     ENTER @Hp4142 USING "#,3X,12D,X";Mdata
170     PRINT "Id(A)=";Mdata
180     END
```

Line Number	Description
10	Assigns the I/O path to control the 4142B.
50 to 70	Defines the measurement channels.
90	Specifies the data output format.
100	Enables the measurement units.
110 to 130	Forces the dc voltage to S_ch, G_ch and D_ch.
140	Executes the high-speed spot measurement (Id).
150	Disables the measurement units.
160 to 170	Reads the measurement data and prints the data on the screen.

The 4142B program modified for use with the 4155C/4156C:

```
10      ASSIGN @Hp415x TO 800                   <-- 1
20      INTEGER G_ch,D_ch,S_ch
30      INTEGER Source,Drain,Gate,Sub,Err       <-- 2
40     !        !Source:    GNDU
50      G_ch=2  !Gate:      HPSMU (SLOT2)
60      D_ch=3  !Drain:     MPSMU (SLOT3)
70      S_ch=4  !Substrate: MPSMU (SLOT4)
80      Source=1       !1:SMU1                  <-- 2
90      Drain=2        !2:SMU2                  <-- 2
100     Gate=3         !3:SMU3                  <-- 2
110     Sub=4          !4:SMU4                  <-- 2
120     OUTPUT @Hp415x;"US42"                   <-- 3
130     OUTPUT @Hp415x;"ACH ";Drain,D_ch        <-- 2
140     OUTPUT @Hp415x;"ACH ";Gate,G_ch         <-- 2
150     OUTPUT @Hp415x;"ACH ";Sub,S_ch          <-- 2
160    !
170     OUTPUT @Hp415x;"FMT 1"                  <-- 4
180     OUTPUT @Hp415x;"CN ";D_ch,G_ch,S_ch     <-- 4
190     OUTPUT @Hp415x;"DV ";S_ch;",0,0,.1"     <-- 4
200     OUTPUT @Hp415x;"DV ";G_ch;",0,3,.01"    <-- 4
210     OUTPUT @Hp415x;"DV ";D_ch;",0,5,.1"     <-- 4
220     OUTPUT @Hp415x;"CN ";Source             <-- 5
230     OUTPUT @Hp415x;"DV ";Source;",11,0,.1" <-- 5
240     OUTPUT @Hp415x;"TI ";D_ch;",0"          <-- 4
250     OUTPUT @Hp415x;"CL"
260     ENTER @Hp415x USING "#,3X,12D,X";Mdata
270     PRINT "Id(A)=";Mdata
280     OUTPUT @Hp415x;":PAGE"                  <-- 3
290     END
```

Ref No.	Note
1	GPIB address is changed.
2	Program lines are added to assign the new channel numbers.
3	Program lines are added to use the FLEX command control mode.
4	A space is inserted between the command and the first parameter.
5	Program lines are added to control the channel for the source (the original 4142B program used GNDU as the source. The 4142B GNDU command does not require the control command).

Programming Tips

This section provides the following additional information on creating measurement programs.

- “Confirming Operation Status”
- “Improving Measurement Speed”
- “Disabling Auto Calibration”

Confirming Operation Status

To complete the measurement program, you can insert statements to check the 4155C/4156C operation status as shown below. This example checks the status caused by the statements before the :SYST:ERR? command, reads and displays the measurement data without errors, or displays an error message when an error occurs.

```
OUTPUT @Hp415x;":SYST:ERR?"
ENTER @Hp415x;Code,Msg$
IF Code=0 THEN
  OUTPUT @Hp415x;"RMD? 1"
  ENTER @Hp415x USING "#,5X,13D,X";Mdata
  PRINT "I(A)=";Mdata
ELSE
  PRINT "ERROR:";Msg$
END IF
END
```

It is important to execute the operation status check before executing the TI?, TV?, or RMD? commands, which wait for the output data and reads the measurement results. If these commands are entered when the 4155C/4156C is in an error state, the 4155C/4156C will *not* return the measurement data, and will enter the wait state. Enter the device clear command (for example, the CLEAR command in HP BASIC). The 4155C/4156C will recover to normal state in approximately two seconds.

Improving Measurement Speed

To improve measurement speed:

- optimize the measurement range
- optimize the integration time
- use binary output format
- use the internal program memory
- use the TI?/TV? command instead of the TI/TV command

To Optimize the Measurement Range

The most effective way to improve measurement speed is to reduce the number of range changes. The limited autoranging mode is more effective than the autoranging mode. The fixed range mode is the most effective.

Check the typical value of the measurement data, select the optimum range, and use the fixed range mode.

To Optimize the Integration Time

For best repeatability and accuracy of the measurement data, the integration time and the number of averaging samples must be increased. This increases the measurement time.

For low current/voltage measurements, you will *not* want to decrease the integration time and averaging samples.

For medium or high current/voltage measurements, which do *not* need long integration time and numerous samples, decrease the parameter values of the following commands:

SIT/SLI command	Defines and selects the integration time.
AV command	Sets the number of averaging samples.

For more information regarding these commands and changing the parameter values, refer to Chapter 1 of the *GPIB Command Reference*.

If the measurement speed is given top priority or is more important than the measurement accuracy, disable the ADC zero function by using the AZ command. This reduces the integration time to approximately half, if the integration time is set to 10.24 msec or more.

NOTE The ADC zero function must be enabled to satisfy the measurement accuracy specifications.

To Use the Binary Output Format

To specify the data output format, ASCII or binary, use the FMT command.

If you select ASCII format, you can read the measurement data easily. The data transfer time will be longer than the binary data transfer time because the data length is longer in ASCII format.

If your program executes parameter measurements, sweep measurements, and so on, which outputs various measurement data, select the binary format to reduce the data transfer time. To read binary data, refer to “Reading Binary Output Data” on page 3-79.

To Use the Internal Program Memory

If your program repeats the setup and measurements for numerous devices, use the internal program memory. For these measurements, using the internal program memory reduces the command transfer time.

You can enter a maximum of 255 programs (a maximum of 100 KB) into the internal program memory. Refer to “Using Program Memory” on page 3-55.

To Use the TI?/TV? Command Instead of the TI/TV Command

If your program executes high-speed spot measurements, use the TI?/TV? command. The TI?/TV? command does *not* require you to enter the RMD? command, and reduces the RMD? command transfer time.

Disabling Auto Calibration

The auto calibration function triggers the self-calibration automatically every 30 minutes after the measurement. And the calibration requires to open the measurement terminals.

If you execute the automatic measurements as the batch job that may leave the connection with the device over 30 minutes after the measurements, disable the auto calibration. Otherwise the calibration may not be performed properly, or unexpected output may appear at the measurement terminals, and it may damage the device.

To disable the auto calibration, enter the `CM 0` command.

4 Running 4145A/B Program Directly on 4155C/4156C

This chapter describes how to directly run an 4145A/B GPIB program (non-ASP program) on the 4155C/4156C with little or no modification. To run these programs directly, you need to use the *4145 syntax command mode* of the 4155C/4156C.

NOTE

To Enter into 4145 Syntax Command Mode

When the 4155C/4156C is turned on, the 4155C/4156C is always in the 4155C/4156C command mode.

To enter into the 4145 syntax command mode:

- From front-panel

  Set `COMMAND SET` field on the SYSTEM: MISCELLANEOUS screen to `4145`.

- From remote control

  Send ":SYSTem:LANGuage COMPatibility" command to the 4155C/4156C.

Usually, you can run these programs with no modification. But sometimes small modifications are required due to the following, which are described in this chapter:

- Non-supported commands
- Consideration about Differences

Non-supported Commands

The following the 4145A/B commands are not supported in the 4145B syntax command mode:

GL0	Disables HP-GL
GL1	Enables HP-GL overlay graphics
GL2	Enables HP-GL stand-alone graphics
MX	Matrix
SH	Schmoo
SV S	Save ASP file
GT S	Get ASP file
DM3	Display mode Matrix
DM4	Display mode Schmoo
AS1	Auto Sequence Program Start
AS2	Auto Sequence Program Continue
AS3	Auto Sequence Program Stop

If you have the 4145A/B programs that include any of the above commands, they will not work with the 4155C/4156C. Refer to "4145B Syntax Command Set" in *GPIB Command Reference* for details.

Considerations about Differences

The 4155C/4156C is different from the 4145A/B on the following points:

- Spot Measurement
- Sweep Steps in Logarithmic Step Mode
- Terminator

Spot Measurement

The 4145A/B can execute a spot measurement by setting both start and stop of the sweep to the same value, but the 4155C/4156C executes the measurement twice even if you set both start and stop of the sweep to the same value.

Sweep Steps in Logarithmic Step Mode

Calculation algorithm for primary sweep steps in logarithmic step mode is slightly different between the 4155C/4156C and the 4145A/B, so step values and number of steps may be different between the 4155C/4156C and the 4145A/B.

Terminator

If you run your program on an external controller, use <CR> + <LF> as the command terminator if you execute serial polling to read a status of the 4155C/4156C in your program.

If you use only <CR> or <LF> as command terminator, the 4155C/4156C may respond with incorrect status.

This is due to the differences of reading and parsing commands between the 4145A/B and the 4155C/4156C.

The following example and explanation gives a better understanding of this.

```
10 OUTPUT @Hp415x;"ME1"
20 REPEAT
30 Status=SPOLL(@Hp415x)
40 UNTIL BIT(Status,0)
```

line number	Description
10	triggers measurement and clears the data ready bit (bit1) of status register.
20 to 40	waits until the data ready bit of status register is set to 1.

When the Terminator is only <CR>

- 4145A/B

  At line 10:

  1. The 4145A/B starts reading data with RFD line set to false (data bus is halted) after each byte.

     In this example:

     `M → bus halted → E → bus halted → 1 → bus halted`

  2. After receiving `1`, the 4145A/B recognizes valid command `ME1`, then executes `ME1`.

     At this time, the program is paused because the controller is trying to send <CR>, which is a terminator, but the 4145A/B has halted data bus and does not receive <CR>.

  3. After the 4145A/B triggers measurement and clears status bit1, the 4145A/B reads <CR>, then the program proceeds to next step (line 20).

  The program reads the correct status at line 30.

- 4155C/4156C

  At line 10:

  1. The 4155C/4156C starts and continues reading data until reading a terminator.

     In this example, the 4155C/4156C reads `ME1<CR>`, then halts data bus.

  2. The 4155C/4156C starts executing "ME1". At the same time, the external controller can proceed to the next line, because all data of this line has transferred, then program continues.

  At line 30, controller can read status of the 4155C/4156C even if RFD line is false. RFD holdoff is not effective for serial polling.

  However, the clearing of the status register bit by line 10 may not have been completed yet, so line 30 may get the incorrect status.

When the Terminator is <CR> + <LF>

The example program for the 4155C/4156C performs as follows:

1. The 4155C/4156C starts and continues reading data until reading a terminator.

   In this example, the 4155C/4156C reads `ME1<CR>`, then halts data bus.

2. The 4155C/4156C executes "ME1".

   At this time, the program is paused because the controller is trying to send <LF>, which is part of the terminator, but the 4155C/4156C has halted data bus and does not receive <LF>.

3. After the 4155C/4156C triggers measurement and clears the status bit1, the 4155C/4156C reads <LF>, then the program proceeds to next step (line 20).

The program reads the correct status at line 30.

5 ASP-Like IBASIC Programming

ASP means Auto Sequence Programming environment on the 4145A/B semiconductor parameter analyzer. The 4155C/4156C provides the programming environment like ASP by using the built-in Instrument BASIC.

This chapter describes how to create the ASP-like programs, and provides the reference of the ASP-like commands.

- “Creating ASP-like IBASIC Programs”
- “ASP-like Commands”

Creating ASP-like IBASIC Programs

This section introduces how to easily create a program by using the typing aid softkeys in the IBASIC editor. This method of creating a program is similar to using the ASP environment on the 4145A/B semiconductor parameter analyzer.

In the IBASIC editor of the 4155C/4156C, there are several typing aid softkeys that allow you to easily create a program.

When you press the softkey, the corresponding IBASIC command is entered into the program, so you do not have to type it, but you may need to type in some parameters.

For typing aid softkeys, refer to “Keys for IBASIC” in Chapter 1, mainly “Secondary Softkeys in Edit execution status” in Chapter 1 for `EXECUTE`.

For the 4145A/B users, this environment is very familiar because it is similar to the Auto Sequence Program (ASP) programming environment of the 4145A/B. For most of the 4145 ASP commands, the IBASIC editor has a softkey to enter a corresponding IBASIC command.

These programs can run in IBASIC *only*, not on an external computer.

Step 1

Creating Programs by using the Typing Aid Softkeys

In the IBASIC editor, you can easily create programs that perform the same operations as a desired 4145 ASP program by using the typing aid softkeys. These are secondary softkeys. To display more softkeys, select More softkey.

For the ASP program shown below, let's create the corresponding IBASIC program:

```
! ASP Program:          Corresponding IBASIC Program:
!
1 GET P ICBVBE          10 EXECUTE ("GETSETUP 'ICBVBE.PRO'")
2 SINGLE                20 EXECUTE ("SINGLE")
3 SAVE D BV1            30 EXECUTE ("SAVEDATA 'BV1.DAT'")
                        40 END
```

1. Select the GET SETUP secondary softkey. The following appears:

   ```
   10 EXECUTE ("GETSETUP ")
   ```

   You need to specify a filename in this command. At bottom of screen, `enter fileName[,msus]` is displayed, where `msus` means the mass storage unit specifier. You can specify `DISK` or `MEMORY`. Default is `DISK`.

2. Type a setup file name.

```
10 EXECUTE ("GETSETUP 'ICBVBE.PRO'_")
```

   File name must be in single quotations ('). Then press **Enter**.

3. Select SINGLE secondary softkey.

```
10 EXECUTE ("GETSETUP 'ICBVBE.PRO'")
20 EXECUTE ("SINGLE")
30 _
```

4. Select SAVEDATA secondary softkey.

```
10 EXECUTE ("GETSETUP 'ICBVBE.PRO'")
20 EXECUTE ("SINGLE")
30 EXECUTE ("SAVEDATA _")
```

5. Specify file name to which you want to save the measurement setup and result data.

```
10 EXECUTE ("GETSETUP 'ICBVBE.PRO'")
20 EXECUTE ("SINGLE")
30 EXECUTE ("SAVEDATA 'BV1.DAT'")
40 END
```

   Finally, type `END` as above.

NOTE

Setup File

In `EXECUTE ("GETSETUP ")`, you can specify a `.PRO` or `.MES` file:

- `.PRO` files are setup files created by the 4145B. The 4155C/4156C can read `.PRO` files.
- `.MES` files are setup files created by the 4155C/4156C.

In `EXECUTE ("SAVEDATA ")`, you specify a `.DAT` file, which is a file for storing the setup and measurement result data.

Step 2

Executing the Program

To execute the program, exit editor, then press **Run**.

The 4155C/4156C gets the setup file from the diskette, performs measurement, then saves setup and results to specified file on the diskette. However, in All IBASIC mode, no graphics results are displayed. To display results graphically, the display mode must be *All Instrument* mode or *IBASIC Status* mode.

To execute the program and display the results graphically, change the display mode to *All Instrument* or *IBASIC Status* mode, then press **Run**.

Step 3

Creating a Longer Program

In the program below, the left side is an ASP program example from the 4145B manual.

The right side shows a program that was created by using the typing aid softkeys to enter the ASP-like commands (of the 4155C/4156C) that correspond to the original ASP commands. These softkeys allow you to easily create a program that runs on the 4155C/4156C and performs the same operations as the original ASP program.

```
 1 GET P ICBVBE              10 EXECUTE ("GETSETUP 'ICBVBE.PRO'")
 2 SINGLE                    20 EXECUTE ("SINGLE")
 3 WAIT 3                    30 WAIT 3
 4 GET P HFE1                40 EXECUTE ("GETSETUP 'HFE1.PRO'")
 5 SINGLE                    50 EXECUTE ("SINGLE")
 6 WAIT 3                    60 WAIT 3
 7 GET P VCESAT              70 EXECUTE ("GETSETUP 'VCESAT.PRO'")
 8 SINGLE                    80 EXECUTE ("SINGLE")
 9 WAIT 3                    90 WAIT 3
10 GET P COLR               100 EXECUTE ("GETSETUP 'COLR.PRO'")
11 SINGLE                   110 EXECUTE ("SINGLE")
12 WAIT 3                   120 WAIT 3
13 PAUSE                    130 PAUSE
14 GET P NPN1               140 EXECUTE ("GETSETUP 'NPN1.PRO'")
15 SINGLE                   150 EXECUTE ("SINGLE")
16 PAUSE                    160 PAUSE
17 PLOT 100,100,7000,7000   170 EXECUTE ("PRINTPLOT")
18 GET P BV                 180 EXECUTE ("GETSETUP 'BV.PRO'")
19 SINGLE                   190 EXECUTE ("SINGLE")
20 PLOT 100,100,7000,7000   200 EXECUTE ("PRINTPLOT")
21 PAUSE                    210 PAUSE
22 SINGLE                   220 EXECUTE ("SINGLE")
23 CPLOT 100,100,7000,7000  230 EXECUTE ("CURVEPLOT")
                            240 END
```

NOTE

Print/Plot

`EXECUTE ("PRINTPLOT")` prints/plots the information of the present instrument screen, not the IBASIC screen. If present page is GRAPH/LIST: GRAPHICS page, the graph is printed/plotted.

`EXECUTE ("CURVEPLOT")` changes to the GRAPH/LIST: GRAPHICS page, then prints/plots the graph.

You need to set the desired settings on the SYSTEM: PRINT/PLOT SETUP page and PRINT/PLOT dialog before “PRINTPLOT” or “CURVEPLOT” is performed.

To execute the program that sequentially performs “SINGLE” and “PRINTPLOT” or “SINGLE” and “CURVEPLOT” like above example (see lines 190 to 200 and 220 to 230), set the display mode to *All Instrument*, and then press **Run**. If you execute the program in the *IBASIC Status* mode, the program starts printing/plotting without waiting for the measurement completion and causes error.

Programming Tips

This section describes features and tips of IBASIC programs in relation to ASP programs. Some examples use an example measurement setup file named "VTH.MES". Before executing these examples, you need to save setup data to a file named "VTH.MES" on the diskette. For an example setup, see “Example Application Setup for Vth Measurement” in Chapter 2.

File Name Variables

You can specify a string variable for the file name in SAVEDATA as follows:

```
Filename$="DATA1.DAT"
EXECUTE ("SAVEDATA Filename$")
```

This feature allows you to create a more simple program as follows.

Example ASP Program

Following ASP program gets a setup file, makes measurements, and saves results to following files: `VTH1`, `VTH2`, `... VTH10`. Program is 21 lines.

```
 1 GET P VTH
 2 SINGLE
 3 SAVE D VTH1
 4 SINGLE
 5 SAVE D VTH2
 6 SINGLE
     :
     :
21 SAVE D VTH10
```

Corresponding IBASIC Program.

The following Instrument BASIC (IBASIC) program does the same operation as the above ASP program. The program is simplified by using a filename variable `Filename$` and the `FOR NEXT` keyword.

```
10 EXECUTE ("GETSETUP 'VTH.PRO'")
20 FOR I=1 TO 10
30   EXECUTE ("SINGLE")
40   Filename$="VTH"&VAL$(I)&".DAT"
50   EXECUTE ("SAVEDATA Filename$")
60 NEXT I
```

In line 40, the `Filename$` is defined. For example, `Filename$="VTH1.DAT"` when `I`=1. So, the 21-line ASP program can be converted to a 6-line IBASIC program.

Reading 4155/56 Data to IBASIC Variables

You can transfer read-out function values or data variable values (source data, measurement data, and user function values) from the 4155/56 to Instrument BASIC (IBASIC) variables.

Transferring Multiple Data

You can transfer multiple data (such as sweep measurement data) to an array variable of IBASIC by using `EXECUTE ("READDATAVAR ")` as follows:

```
EXECUTE ("READDATAVAR 'ID','Id_data'")
```

The above example transfers the drain current data `ID` of a sweep measurement to the array variable previously defined as `Id_data`.

Following example program gets `VTH.MES` setup file, performs measurement, then transfers `ID` data to an array. In this example, the array `Id_data` is defined in line 10, and it has elements 1 to 51.

```
10 DIM Id_data(1:51)
20 EXECUTE ("GETSETUP 'VTH.MES'")
30 EXECUTE ("SINGLE")
40 EXECUTE ("READDATAVAR 'ID','Id_data'")
50 FOR I=1 TO 51
60 PRINT "Id(";I;")=";Id_data(I);"A"
70 NEXT I
80 END
```

Result with example measurement data is as follows:

```
Id(1)= 0.00031 A
Id(2)= 0.00282 A
Id(3)= 0.00514 A
Id(4)= 0.01017 A
      :
Id(51)= 0.08274 A
```

Transferring a Single Data

In the following example, a single data is to transferred to a variable. For example, VTH is a single data point calculated by a user function that was defined by the user.

```
EXECUTE ("READDATAVAR 'VTH','Vthdata'")
```

In following example, EXECUTE ("READDATAVAR") is used to transfer the VTH value to the IBASIC variable Vthdata. And for example, VTH.MES is a setup file that includes auto analysis setup to extract a threshold voltage VTH.

```
10 EXECUTE ("GETSETUP 'VTH.MES'")
20 EXECUTE ("SINGLE")
30 EXECUTE ("READDATAVAR 'VTH','Vthdata'")
40 PRINT "Vthdata=";Vthdata;"V"
50 END
```

Result will be for example:

```
Vthdata= 1.2345 V
```

You can also specify a read out function as the item to be transferred:

```
EXECUTE ("READDATAVAR '@MX','Vthdata'")
```

@MX is the read out function that reads X-axis value of point where marker is located.

Auto Scaling

Auto scaling can be done by using the following:

```
EXECUTE ("AUTOSCALE")
```

In the following example, the image dumps will be scaled for best fit to the printer or plotter even if the measurement results vary greatly.

```
10 EXECUTE ("GETSETUP 'VTH.MES'")
11 FOR I=1 TO 100
20   EXECUTE ("SINGLE")
30   EXECUTE ("AUTOSCALE")
40   EXECUTE ("PRINTPLOT")
41 NEXTI
50 END
```

4145 ASP and 4155C/4156C Corresponding Keywords

Following shows the 4145A/B's ASP keywords and corresponding 4155C/4156C keywords. In IBASIC editor, there are typing aid softkeys to help you quickly enter the related 4155C/4156C keyword, which must be used in the `EXECUTE` directive:

Corresponding 4145 ASP and 4155C/4156C Keywords

4145A/B	4155C/4156C	Function
GET P	GETSETUP	Gets setup `.MES` or `.PRO` file.
SINGLE	SINGLE	Initiates single measurement.
SAVE D	SAVEDATA	Saves data to `.DAT` file.
PLOT	PRINTPLOT	Prints/plots present instrument page.
CPLOT	CURVEPLOT	Prints/plots measurement graph.
PRINT	PRINTPLOT	Prints/plots present instrument page.
PAUSE	Use BASIC keyword PAUSE	
WAIT	Use BASIC keyword WAIT	
PAGE	Set in the Print/Plot setup	
	STANDBY	Sets Standby status on or off.
	STRESS	Initiates stress force.
	AUTOSCALE	Scales dump for best fit.
	READDATAVAR	Gets data variable from 4155C/56C.
	DEFUSERVAR	Defines user variable.

For WAIT and PAUSE of the 4145's ASP, there are no related typing aid softkeys. You type in the IBASIC keywords (WAIT and PAUSE).

For more information about IBASIC Keywords, use help functions or refer to *Instrument BASIC Users Handbook*.

ASP-like Commands

EXECUTE is an IBASIC keyword for executing function directives, which allow you to easily create simple programs in a way similar to creating Auto Sequence Programs (ASP) on the 4145A/B Semiconductor Parameter Analyzer.

NOTE

Compatibility Consideration

EXECUTE is *not* a standard IBASIC or HP BASIC keyword. So, if you use this keyword in your program, it will *not* execute on another IBASIC or HP BASIC system.

EXECUTE

Keyboard Executable	Yes
Programmable	Yes
In an IF . . . THEN . . .	Yes

This keyword can execute the function directives that are described on the following pages.

Syntax

EXECUTE ("*directive_keyword* [*parameter*]")

directive

Some directives require parameters. There must be one or more spaces between *directive_keyword* and *parameter*.

The following pages describe the *directives* that can be used in the EXECUTE command.

Textual Notation

[ ]	Square brackets are used to enclose optional information not required for execution of the command sequence.
|	The vertical bar can be read as "or" and is used to separate alternative parameter options.

GET SETUP Directive

This directive loads the specified 4155C/4156C setup file.

Directive syntax

GETSETUP *file_name* [, DISK | MEMORY]

Directive parameter

Parameter	Type	Explanation
file_name	string	name of setup file with extension (.MES or .STR) to be loaded. You must enclose the name with single quotes or double-double quotes.
DISK	character	(default) loads setup data from a diskette into the built-in flexible disk drive.
MEMORY	character	loads setup data from internal memory.

Example

```
EXECUTE ("GETSETUP 'SWEEP.MES'")
EXECUTE ("GETSETUP 'SWEEP.MES','DISK'")
EXECUTE ("GETSETUP File$,'DISK'")
EXECUTE ("GETSETUP 'MEM1.MES','MEMORY'")
```

SINGLE Directive

This directive executes measurement.

Directive syntax

SINGLE

Example

```
EXECUTE ("SINGLE")
```

STANDBY directive

This directive changes `STBY ON` channels to standby state or idle state.

Directive syntax

STANDBY ON | OFF

Directive parameter

Parameter	Type	Explanation
ON	character	changes `STBY ON` channels from idle state to standby state.
OFF	character	changes `STBY ON` channels from standby state to idle state.

Example

```
EXECUTE ("STANDBY ON")
EXECUTE ("STANDBY OFF")
```

STRESS Directive

This directive forces stress.

Directive syntax

STRESS

Example

```
EXECUTE ("STRESS")
```

AUTO-SCALE Directive

This directive changes page to GRAPH/LIST: GRAPHICS and executes auto-scaling function.

Directive syntax

AUTOSCALE

Example

```
EXECUTE ("AUTOSCALE")
```

SAVE DATA Directive

This directive stores measurement data file to a diskette into the built-in flexible disk drive or internal memory.

Directive syntax

SAVEDATA *file_name* [, DISK | MEMORY]

Directive parameter

Parameter	Type	Explanation
file_name	string	name of measurement data file with extension (.DAT) to be stored. You must enclose the name with single quotes or double-double quotes.
DISK	character	(default) stores measurement data to a diskette into the built-in flexible disk drive.
MEMORY	character	stores measurement data to internal memory.

Example

```
EXECUTE ("SAVEDATA 'SWEEP.DAT'")
EXECUTE ("SAVEDATA 'SWEEP.DAT','DISK'")
EXECUTE ("SAVEDATA File$,'DISK'")
EXECUTE ("SAVEDATA 'MEM1.DAT','MEMORY'")
```

READ DATA VARIABLE Directive

This directive gets values of specified 4155C/4156C data variable, and stores the values in an IBASIC variable.

Directive syntax

READDATAVAR *data_variable_name*, *ibasic_variable_name*

Directive parameter

Parameter	Type	Explanation
data_variable_name	string	name of the data variable of the 4155C/4156C. You must enclose the name with single quotes or double-double quotes. Name is case sensitive.
ibasic_variable_name	string	name of numeric variable or numeric array of IBASIC program. *ibasic_variable_name* is not case sensitive.

Example

```
EXECUTE ("READDATAVAR 'V1','V'")
```

DEFINE USER VARIABLE Directive

This directive defines an 4155C/4156C user variable, and transfers values from an IBASIC variable to the user variable.

Directive syntax

DEFUSERVAR *user_variable_name,no_of_points,ibasic_variable_name* [, *unit*]

Directive parameter

Parameter	Type	Explanation
user_variable_name	string	user variable name that you want to define. You must enclose the name with single quotes or double-double quotes.
no_of_points	numeric	number of data for the user variable.
ibasic_variable_name	string	name of numeric variable or numeric array of IBASIC program. The data in this variable will be transferred to the user variable.
unit	string	unit of user variable. You must enclose the unit with single quotes or double-double quotes.

Example

```
EXECUTE ("DEFUSERVAR 'U_var',101,'Vth','V'")
```

PRINT/PLOT Directive

This directive prints/plots the information of the present instrument page, not the IBASIC screen. If present page is GRAPH/LIST: GRAPHICS page, the graph is printed/plotted.

You need to set the desired settings on the SYSTEM: PRINT/PLOT SETUP page and PRINT/PLOT dialog before executing `EXECUTE ("PRINTPLOT")`.

Directive syntax PRINTPLOT

Example

```
EXECUTE ("PRINTPLOT")
```

CURVE PLOT Directive

This directive changes to GRAPH/LIST: GRAPHICS page, then prints/plots the graph.

You need to set the desired settings on the SYSTEM: PRINT/PLOT SETUP page and PRINT/PLOT dialog before executing `EXECUTE ("CURVEPLOT")`.

Directive syntax CURVEPLOT

Example

```
EXECUTE ("CURVEPLOT")
```

NOTE

To Execute “PRINTPLOT” or “CURVEPLOT”

To execute the program that sequentially performs “SINGLE” and “PRINTPLOT” or “SINGLE” and “CURVEPLOT” as shown in the example below, set the display mode to *All Instrument*, and then press **Run**. If you execute the program in the *IBASIC Status* mode, the program starts printing/plotting without waiting for the measurement completion and causes error.

```
10 EXECUTE ("GETSETUP 'SWEEP.MES'")
20 EXECUTE ("SINGLE")
30 EXECUTE ("PRINTPLOT")
40 END
```

```
10 EXECUTE ("GETSETUP 'SWEEP.MES'")
20 EXECUTE ("SINGLE")
30 EXECUTE ("CURVEPLOT")
40 END
```