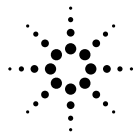


Programmer's Guide

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



Agilent Technologies

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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 General Information* 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. |
| <i>Italic</i> | Refers to a related document, or is used for emphasis. |

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1 **Using Instrument BASIC**

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.

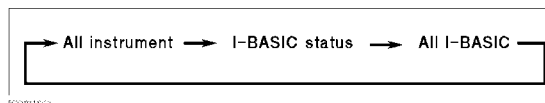
- "All Instrument" screen

.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 <i>screen group</i> 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
```

Using Instrument BASIC

Modifying Program by using Editor Functions

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 <i>false</i> . |
| REPEAT, UNTIL | Repeat until specified condition is <i>true</i> . |

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.

Using Instrument BASIC

IBASIC Basic Operation Tasks

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 :PROG:[: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. |

Using Instrument BASIC

Controlling IBASIC from External Computer

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

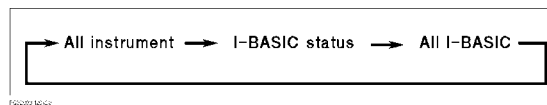
Softkeys and bottom two lines are used for IBASIC. Rest of screen is for instrument setup screen.

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.

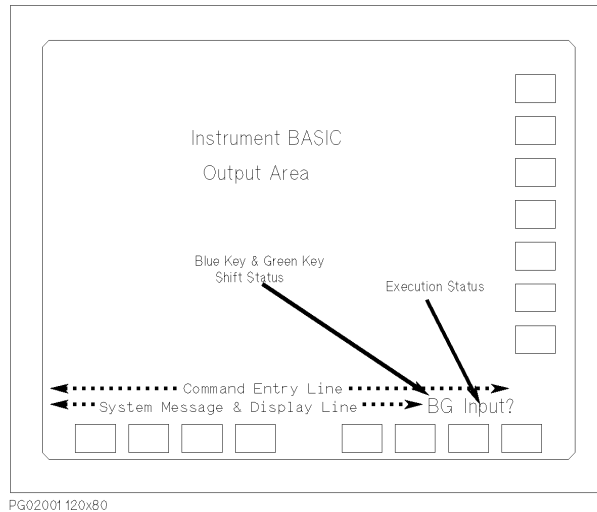
- "All Instrument" screen

.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. |

Using Instrument BASIC IBASIC Screen

Blue Key & Green Key Shift Status

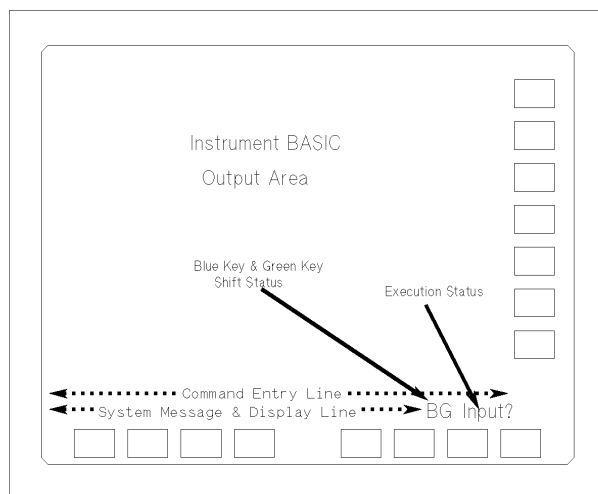
This field displays the shift status of ENTRY front-panel keys. The shift status is controlled by using the blue and green front-panel keys:

The following statuses are displayed:

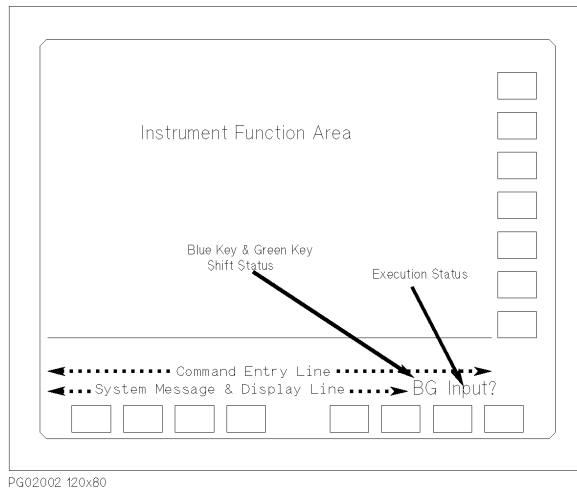
- Non-shift status: B, b, or G is not displayed. You can enter numeric values.
- Uppercase shift status: B is displayed, G is not displayed. You can enter uppercase alphabet characters.
- Lowercase shift status: b is displayed. G is not displayed. You can enter lowercase alphabet characters.
- Non-alphanumeric 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.



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**

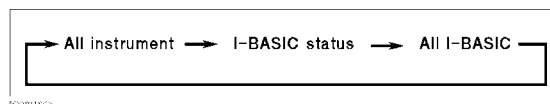
- In "IBASIC Status" screen:
 - Single, Repeat, Append** Changes the display to GRAPH/LIST: GRAPHICS or GRAPH/LIST: LIST screen and executes the measurement.
 - Standby** Toggles the operation state of the standby channels between the standby state and the idle state.
 - Stop** Stops the measurement 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.



Using Instrument BASIC

Keys for IBASIC

| | | |
|------------------------|------------------|--|
| ENTRY key group | Recall↓ | <ul style="list-style-type: none">• 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↑ | <ul style="list-style-type: none">• 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 | <p>If present screen is "All IBASIC", dumps "All IBASIC" screen image to the printer or plotter.</p> <p>If present screen is "IBASIC Status", prints/plots instrument part of screen.</p> |

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 | <ol style="list-style-type: none">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 <code>COM</code> . Before clearing, <code>YES</code> and <code>NO</code> 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 VARIABLE

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 VARIABLE

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.

Using Instrument BASIC Keys for IBASIC

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.

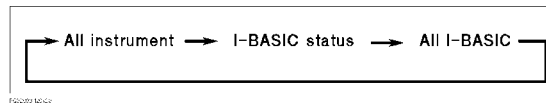
In this section, the notation "**KeyA+KeyB**" means to hold down **KeyA** and press **KeyB**.

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**.

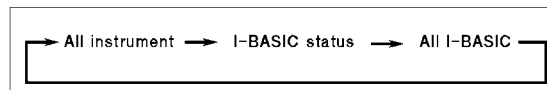
Using Instrument BASIC Keys for IBASIC

| | |
|---------------------|--|
| Insert | <p>Insert. Same as Alt+I.</p> <p>When the editor is running, opens a new line before the current line.</p> <p>When the editor is not running, inserts text at the cursor (press Insert again to end insert mode).</p> |
| Shift+Insert | <p>Insert. Same as Insert.</p> |
| Delete | <p>Delete. Deletes character at the cursor.</p> |
| Shift+Delete | <p>Delete line. Same as Alt+D.</p> <p>When the editor is running, deletes the current line.</p> <p>When the editor is not running, deletes character at cursor.</p> |
| Ctrl+Delete | <p>Clear to end. Deletes characters from cursor to end of line. Same as F11.</p> |
| Home | <p>Beginning of line. Moves the cursor to beginning of the line. Same as Shift+ ←.</p> |
| Shift+Home | <p>Page move.</p> <p>When the editor is running, same as Page Up. Also, same as Shift+ ↑.</p> <p>When the editor is not running, jumps to the top of the IBASIC output area. Also, same as Shift+ ↓.</p> |
| End | <p>End of line. Moves cursor to end of line. Same as Shift+ ⇒.</p> |
| Shift+End | <p>Page move.</p> <p>When the editor is running, same as Page Down. Also, same as Shift+ ↓.</p> <p>When the editor is not running, jumps to the bottom of the IBASIC output area. Same as Shift+ ↑.</p> |
| Page Up | <p>Page move.</p> <p>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+ ↑.</p> <p>When the editor is not running, moves display down one page.</p> |

| | |
|------------------------|--|
| Shift+Page Up | <p>Recall.</p> <p>When the editor is running, displays last deleted line. To enter line into program, press Enter.</p> <p>When the editor is not running, cycles through the 10 commands that were most recently entered on the Command Entry line.</p> |
| Page Down | <p>Page move.</p> <p>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+↓.</p> <p>When the editor is not running, moves display up one page.</p> |
| Shift+Page Down | <p>Recall backward.</p> <p>When the editor is running, same as Shift+Page Up.</p> <p>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.</p> |
| ↑ | <p>Previous line.</p> <p>When the editor is running, moves cursor up one line.</p> <p>When the editor is not running, display on the IBASIC output area moves one line toward the end.</p> |
| Shift+↑ | <p>Page move.</p> <p>When the editor is running, same as Page Up. Also, same as Shift+Home.</p> <p>When the editor is not running, jumps to the bottom of the IBASIC output area. Same as Shift+End.</p> |
| Alt+↑ | <p>Recall backward.</p> <p>When the editor is running, same as Shift+Page Up.</p> <p>When the editor is not running, same as Shift+Page Down.</p> |
| ↓ | <p>Next line.</p> <p>When the editor is running, cursor moves down one line.</p> <p>When editor is not running, display on IBASIC output area moves one line toward beginning.</p> |

Using Instrument BASIC Keys for IBASIC

| | |
|------------------|---|
| 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: |



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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*.

| <i>pen selector</i> | 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. |

Using Instrument BASIC

4155C/4156C Specific IBASIC Keywords

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.

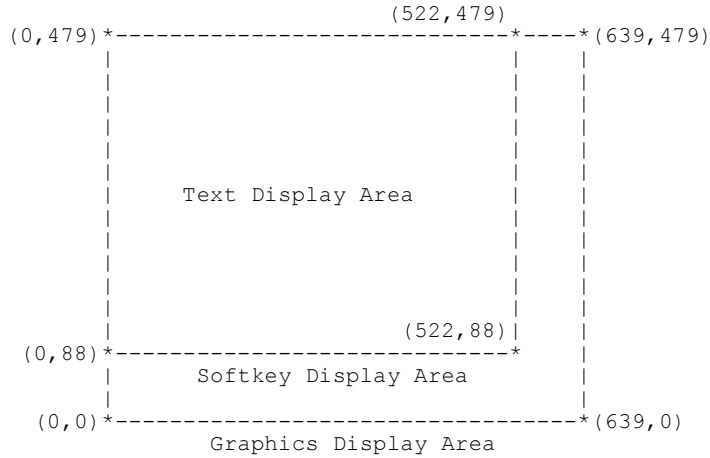
| Select Code | Interface |
|-------------|-----------------------------------|
| 1 | LCD |
| 2 | External and front-panel keyboard |
| 7 | GPIB Interface on rear panel |
| 8 | Internal pseudo GPIB Interface |
| 9 | Parallel Interface |

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.



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 cover 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 | $(9 \times (N-1), 479 - 17 \times M)$ | $(9 \times (N-1), 483 - 17 \times M)$ |
| Upper Right Corner | $(9 \times N, 479 - 17 \times (M-1))$ | $(9 \times N-4, 476 - 17 \times (M-1))$ |

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.

Using Instrument BASIC
Available I/O Resources for IBASIC

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

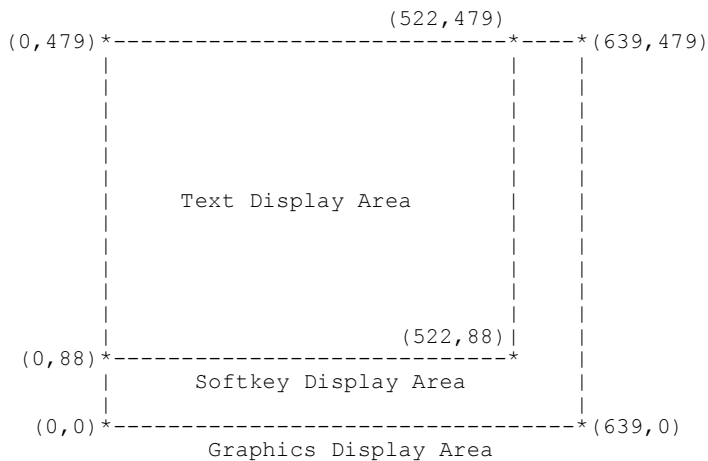
By the difference of the screen, the 4155C/4156C display area is different from the 4155A/4156A as shown in the following table. So if you execute the IBASIC program for the 4155A/4156A on the 4155C/4156C built-in IBASIC controller, the graphics will lie on the text.

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.



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 | $(9 \times (N-1), 479 - 17 \times M)$ | $(9 \times (N-1), 483 - 17 \times M)$ |
| Upper Right Corner | $(9 \times N, 479 - 17 \times (M-1))$ | $(9 \times N-4, 476 - 17 \times (M-1))$ |

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 | HRPCI | HPGL | TIFF | HRTiff |

a. high resolution PCL.

b. high resolution TIFF.

The meaning of the parameters is as follows:

PCL Selects PCL format.

HRPCI 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.

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 |

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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.

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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
```

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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 <code>:DATA?</code> query command to read the result value of user function "VTH". |
| Line 450 | Store the result value into <code>Vth</code> 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 if 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
```

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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
```

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```
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 V_{th} 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:

$$I_d = \beta \times (V_g - V_{th})^2$$

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

$$\sqrt{I_d} = \sqrt{\beta} \times (V_g - V_{th})$$

$\sqrt{I_d}$ is proportional to V_g , and the slope is $\sqrt{\beta}$. At the point where $\sqrt{I_d}$ is equal 0, V_{th} is equal to V_g . So, to know V_{th} , 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 |

SCPI Command Programming

Programming: Measurement 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

*LINE1:[NORMAL] line on [Y1] between a point [AT ]
X:[ 2 ]
Y:[ 3 ]
and a point [WHERE] 4
[AFTER] [ ] = [ ]
[AFTER] [ ] = [ ]
*LINE2:[REGRESSION] line on [Y1] between a point [WHERE]
[AFTER] [ ] = [ ]
and a point [AT ]
X:[ 13 ]
Y:[ 14 ]

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

*Interpolate:[ON ]

NORMAL
Select Line Mode with softkey or rotary knob.

```

1 NORMAL
 2
 3
 4
 5
 6
 7 TANGENT
 8
 9
 10
 11 REGRES- SION
 12
 13
 14
 DISABLE

DISPLAY ANALYSIS [] [] S [] [] PREV NEXT
 SETUP SETUP 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

SCPI Command Programming

Programming: Auto Analysis Setup

Figure 2-2

Tangent Line, Gradient Line, and Marker

```

DISPLAY: ANALYSIS SETUP                                01JAN10 05:38PM

```

| | | |
|--|---|--|
| | <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> 1 2 </div> <pre> 3 *LINE1:[TANGENT] line on [Y1] at a point where [] = [] [AFTER] [] = [] 4 5 </pre> | <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">NORMAL</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">GRAD</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">TANGENT</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">REGRES- SION</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;"> </div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;"> </div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">DISABLE</div> |
| | <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> 6 7 8 </div> <pre> *LINE2:[GRAD] line on [Y1] at a point [AT] X:[9] Y:[10] Gradient: [11] </pre> | |
| | <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> 12 13 14 </div> <pre> *MARKER: At a point where [] = [] [AFTER] [] = [] *Interpolate:[ON] 15 </pre> | |

TANGENT
Select Line Mode with softkey or rotary knob. B

| | | | | | | | |
|------------------|------------------|--|--|---|--|--------------|--------------|
| DISPLAY SETUP | ANLYSIS SETUP | | | S | | PREV PAGE | NEXT PAGE |
|------------------|------------------|--|--|---|--|--------------|--------------|

- 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
```

SCPI Command Programming
Programming: Measurement Execution

| 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
```

SCPI Command Programming
Programming: Measurement Execution

| 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”

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 Chapter 5 of *SCPI Command Reference*.

To connect the 4155C/4156C to your LAN, refer to Chapter 2 of *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 <code>SWP.MES</code> . |

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 <code>SWP.DAT</code> . |

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 <code>SWP.MES</code> . |

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 <code>SWP.DAT</code> . |

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. |

SCPI Command Programming

Programming: Data Transfer

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 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 Chapter 2 of *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 Chapter 5 of *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.

SCPI Command Programming
 Programming: Print/Plot Operation

- 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;" :HCOPI:ITEM:PNUM:STAT OFF"
100 OUTPUT @Hp415x;" :HCOPI: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. |

SCPI Command Programming
 Programming: Print/Plot Operation

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
```

SCPI Command Programming
 Programming: Print/Plot Operation

| 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
```

SCPI Command Programming
Programming: Print/Plot Operation

```
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. |

SCPI Command Programming

Programming: Print/Plot Operation

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
```

SCPI Command Programming
 Programming: Print/Plot Operation

| 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 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 Chapter 5 of *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`.

MEMno Files

If any files named `MEMno.DAT`, `MEMno.MES`, or `MEMno.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 `MEMno` 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 controller, 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. |

SCPI Command Programming

Other Programming Tips

- 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.

SCPI Command Programming
Programming Example for 4145 Users

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

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. |
| <i>parameter</i> | Required command parameter. A value or variable <i>must</i> be specified. |
| [<i>parameter</i>] | Optional command parameter. A value may be specified. |

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Filter ON/OFF | [FL] | <i>mode</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Averaging Number | [AV] | <i>number</i> [, <i>mode</i>] |
| Sets Integration Time | [SIT] | <i>type,time</i> |
| | [SLI] | <i>type</i> |
| Forces constant voltage | DV | <i>chnum,range,output</i> [, <i>Icomp</i>] |
| Forces constant current | DI | <i>chnum,range,output</i> [, <i>Vcomp</i>] |
| Measures current | TI | <i>chnum,range</i> |
| Measures voltage | TV | <i>chnum,range</i> |
| Reads measurement data (for TI/TV command) | RMD? | <i>number_of_data</i> |
| Measures current and reads data | TI? | <i>chnum,range</i> |
| Measures voltage and reads data | TV? | <i>chnum,range</i> |

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. |

FLEX Command Programming

High-Speed Spot Measurements

```

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Filter ON/OFF | [FL] | <i>mode</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Averaging Number | [AV] | <i>number</i> [, <i>mode</i>] |
| Sets Integration Time | [SIT] | <i>type,time</i> |
| | [SLI] | <i>type</i> |
| Forces constant voltage | DV | <i>chnum,range,output</i> [, <i>Icomp</i>] |
| Forces constant current | DI | <i>chnum,range,output</i> [, <i>Vcomp</i>] |
| Sets VMU measurement mode | [VM] | <i>chnum,mode</i> |
| Sets current measurement range | [RI] | <i>chnum,range</i> [, <i>Rmode</i>] |
| Sets voltage measurement range | [RV] | <i>chnum,range</i> [, <i>Rmode</i>] |
| Selects measurement mode | MM | 1, <i>chnum</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets SMU measurement mode | [CMM] | <i>chnum,mode</i> |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

FLEX Command Programming

Spot Measurements

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:Compliance Side 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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Filter ON/OFF | [FL] ^a | <i>mode</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Averaging Number | [AV] ^b | <i>number</i> [, <i>mode</i>] |
| Sets Integration Time | [SIT] | <i>type</i> , <i>time</i> |
| | [SLI] ^b | <i>type</i> |
| Forces constant voltage | [DV] | <i>chnum</i> , <i>range</i> , <i>output</i> [, <i>Icomp</i>] |
| Forces constant current | [DI] | <i>chnum</i> , <i>range</i> , <i>output</i> [, <i>Vcomp</i>] |
| Sets pulse source timing parameters | PT | <i>hold</i> , <i>width</i> [, <i>period</i> [, <i>trigger_delay</i> [, <i>priority</i>]]] |
| Forces pulse voltage | PV | <i>chnum</i> , <i>range</i> , <i>base</i> , <i>pulse</i> [, <i>Icomp</i>] |
| Forces pulse current | PI | <i>chnum</i> , <i>range</i> , <i>base</i> , <i>pulse</i> [, <i>Vcomp</i>] |
| Sets current measurement range | [RI] | <i>chnum</i> , <i>range</i> [, <i>Rmode</i>] |
| Sets voltage measurement range | [RV] | <i>chnum</i> , <i>range</i> [, <i>Rmode</i>] |
| Selects measurement mode | MM | 3, <i>chnum</i> [, <i>chnum</i> ... [, <i>chnum</i>] ..] ^c |
| Sets SMU measurement mode | [CMM] | <i>chnum</i> , <i>mode</i> |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

- 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 μ sec.
- c. If the PT command *priority* parameter specifies the "keep pulse width" mode, the available number of *chnums* is 1.

FLEX Command Programming 1 Channel Pulsed Spot Measurements

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. |

FLEX Command Programming

1 Channel Pulsed Spot Measurements

```

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Filter ON/OFF | [FL] | <i>mode</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Averaging Number | [AV] | <i>number</i> [, <i>mode</i>] |
| Sets Integration Time | [SIT] | <i>type,time</i> |
| | [SLI] | <i>type</i> |
| Sets sweep source timing parameter | [WT] | <i>hold,delay</i> [, <i>step delay</i>] |
| Sets staircase sweep source | WV | <i>ch,mode,range,start,stop,step</i> [, <i>Icomp</i> [, <i>Pcomp</i> [, <i>Rmode</i>]]] |
| | WI | <i>ch,mode,range,start,stop,step</i> [, <i>Vcomp</i> [, <i>Pcomp</i> [, <i>Rmode</i>]]] |
| Sets sweep abort function | [WM] | <i>abort</i> [, <i>post</i>] |
| Sets synchronous sweep source ^a | [WSV] | <i>ch,range,start,stop</i> [, <i>Icomp</i> [, <i>Pcomp</i> [, <i>Rmode</i>]]] |
| | [WSI] | <i>ch,range,start,stop</i> [, <i>Vcomp</i> [, <i>Pcomp</i> [, <i>Rmode</i>]]] |
| Forces constant voltage | [DV] | <i>chnum,range,output</i> [, <i>Icomp</i>] |
| Forces constant current | [DI] | <i>chnum,range,output</i> [, <i>Vcomp</i>] |
| Sets VMU measurement mode | [VM] | <i>chnum,mode</i> |
| Sets current measurement range | [RI] | <i>chnum,range</i> [, <i>Rmode</i>] |

FLEX Command Programming
Staircase Sweep Measurements

| Function | FLEX Command | Parameters |
|--------------------------------|---------------------|--|
| Sets voltage measurement range | [RV] | <i>chnum,range[,Rmode]</i> |
| Selects measurement mode | MM | <i>2,chnum[,chnum ... [,chnum] ...]</i> |
| Sets SMU measurement mode | [CMM] | <i>chnum,mode</i> |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

- 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. |

FLEX Command Programming

Staircase Sweep Measurements

```

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. |

FLEX Command Programming Staircase Sweep Measurements

```

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). |

FLEX Command Programming

Staircase Sweep Measurements

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 measurement range. |

FLEX Command Programming Staircase Sweep Measurements

```

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 | [<i>chnum</i> ... [<i>,chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [<i>,chnum</i>] ...] |
| Sets Filter ON/OFF | [FL] ^a | <i>mode</i> [, <i>chnum</i> ... [<i>,chnum</i>] ...] |
| Sets Averaging Number | [AV] ^b | <i>number</i> [, <i>mode</i>] |
| Sets Integration Time | [SIT] | <i>type,time</i> |
| | [SLI] ^b | <i>type</i> |
| Sets pulse source timing parameters | PT | <i>hold,width</i> [, <i>period</i> [<i>,trigger_delay</i> [<i>,priority</i>]]] |
| Sets pulsed sweep source | PWV | <i>ch,mode,range,base,start,stop,step</i> [, <i>Icomp</i> [<i>,Rmode</i>]] |
| | PWI | <i>ch,mode,range,base,start,stop,step</i> [, <i>Vcomp</i> [<i>,Rmode</i>]] |
| Sets sweep abort function | [WM] | <i>abort</i> [, <i>post</i>] |
| Sets synchronous sweep source ^c | [WSV] | <i>ch,range,start,stop</i> [, <i>Icomp</i> [<i>,Pcomp</i> [<i>,Rmode</i>]]] |
| | [WSI] | <i>ch,range,start,stop</i> [, <i>Vcomp</i> [<i>,Pcomp</i> [<i>,Rmode</i>]]] |
| Forces constant voltage | [DV] | <i>chnum,range,output</i> [, <i>Icomp</i>] |
| Forces constant current | [DI] | <i>chnum,range,output</i> [, <i>Vcomp</i>] |
| Sets current measurement range | [RI] | <i>chnum,range</i> [, <i>Rmode</i>] |

| Function | FLEX Command | Parameters |
|--------------------------------|--------------|---|
| Sets voltage measurement range | [RV] | <i>chnum,range[,Rmode]</i> |
| Selects measurement mode | MM | <i>4,chnum[,chnum ... [,chnum] ..]</i> ^d |
| Sets SMU measurement mode | [CMM] | <i>chnum,mode</i> |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

- 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 μ sec.
- 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 *chnums* is 1.

FLEX Command Programming

Pulsed Sweep Measurements

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. |

FLEX Command Programming Pulsed Sweep Measurements

```

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. |

FLEX Command Programming

Pulsed Sweep Measurements

```

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 | <i>[chnum ... [,chnum] ...]</i> |
| Disables Measurement Units | CL | <i>[chnum ... [,chnum] ...]</i> |
| Sets Filter ON/OFF | [FL] ^a | <i>mode[,chnum ... [,chnum] ...]</i> |
| Sets Averaging Number | [AV] ^b | <i>number[,mode]</i> |
| Sets Integration Time | [SIT] | <i>type,time</i> |
| | [SLI] ^b | <i>type</i> |
| Sets pulse source timing parameters | PT | <i>hold,width[,period [,trigger_delay[,priority]]]</i> |
| Forces pulse voltage | PV | <i>chnum,range,base,pulse[,Icomp]</i> |
| Forces pulse current | PI | <i>chnum,range,base,pulse [,Vcomp]</i> |
| Sets staircase sweep source | WV | <i>ch,mode,range,start,stop,step [,Icomp[,Pcomp[,Rmode]]]</i> |
| | WI | <i>ch,mode,range,start,stop,step [,Vcomp[,Pcomp[,Rmode]]]</i> |
| Sets sweep abort function | [WM] | <i>abort[,post]</i> |
| Forces constant voltage | [DV] | <i>chnum,range,output[,Icomp]</i> |
| Forces constant current | [DI] | <i>chnum,range,output[,Vcomp]</i> |
| Sets current measurement range | [RI] | <i>chnum,range[,Rmode]</i> |

FLEX Command Programming
 Staircase Sweep with Pulsed Bias Measurements

| Function | FLEX Command | Parameters |
|--------------------------------|--------------|---|
| Sets voltage measurement range | [RV] | <i>chnum,range[,Rmode]</i> |
| Selects measurement mode | MM | <i>5,chnum[,chnum ... [,chnum] ..]</i> ^c |
| Sets SMU measurement mode | [CMM] | <i>chnum,mode</i> |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

- 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 μ sec.
- c. If the PT command *priority* parameter specifies the "keep pulse width" mode, the available number of *chnums* is 1.

FLEX Command Programming Staircase Sweep with Pulsed Bias Measurements

A program example of a staircase sweep with pulsed bias measurement is shown below. This program executes the bipolar transistor I_c - V_c 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. |

FLEX Command Programming

Staircase Sweep with Pulsed Bias Measurements

```

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. |

FLEX Command Programming Staircase Sweep with Pulsed Bias Measurements

```

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Filter ON/OFF | [FL] | <i>mode</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets Averaging Number | [AV] ^a | <i>number</i> [, <i>mode</i>] |
| Sets Integration Time | [SIT] | <i>type</i> , <i>time</i> |
| | [SLI] ^a | <i>type</i> |
| Sets the timing parameters | MT | <i>hold</i> , <i>interval</i> , <i>points</i> |
| Source setup | MV | <i>ch</i> , <i>range</i> , <i>base</i> , <i>bias</i> [, <i>Icomp</i>] |
| | MI | <i>ch</i> , <i>range</i> , <i>base</i> , <i>bias</i> [, <i>Vcomp</i>] |
| | MP | <i>ch</i> , <i>mode</i> , <i>base</i> , <i>bias</i> [, <i>Td</i> , <i>Tw</i> , <i>Tl</i> , <i>Tt</i> , <i>Tp</i> , <i>count</i>] ^b |
| Clears the sampling source settings | [MCC] | [<i>ch</i> [, <i>ch</i> ... [, <i>ch</i> [, <i>ch</i>] ...]] |
| Sets automatic abort condition | [MSC] | <i>abort</i> |
| Forces constant voltage | [DV] | <i>chnum</i> , <i>range</i> , <i>output</i> [, <i>Icomp</i>] |
| Forces constant current | [DI] | <i>chnum</i> , <i>range</i> , <i>output</i> [, <i>Vcomp</i>] |
| Sets VMU measurement mode | [VM] | <i>chnum</i> , <i>mode</i> |
| Sets current measurement range | [RI] | <i>chnum</i> , <i>range</i> [, <i>Rmode</i>] |

| Function | FLEX Command | Parameters |
|--------------------------------|--------------|---|
| Sets voltage measurement range | [RV] | <i>chnum,range[,Rmode]</i> |
| Selects measurement mode | MM | 10, <i>chnum</i> [, <i>chnum</i> ..[, <i>chnum</i>] ..] ^c |
| Sets SMU measurement mode | [CMM] | <i>chnum,mode</i> |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

- 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 *chnums* is 1.

FLEX Command Programming

Sampling Measurements

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. |

FLEX Command Programming Sampling Measurements

```

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. |

FLEX Command Programming

Sampling Measurements

```

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables measurement units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Turns the filter on/off | [FL] | <i>onoff</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets the measurement mode | MM | 13[, <i>chnum</i>] |
| Sets zero cancel | [QSZ] | <i>onoff</i> |
| Sets the leak measurement/ leak compensation | [QSL] | <i>data_onoff,compen_onoff</i> |
| Sets the abort function | [QSM] | <i>condition</i> [, <i>result</i>] |
| Sets the measurement range | QSR | <i>range</i> |
| Sets the timing parameters | QST | <i>cinteg,linteg,hold,delay1</i> [, <i>delay2</i>] |
| Sets the sweep source | QSV | <i>chnum,swpmode,range,start,stop</i> <i>,cvoltage,step</i> [, <i>Icomp</i>] |
| Forces the constant source | DV | <i>chnum,range,output</i> [, <i>Icomp</i>] |
| Executes a measurement | XE | |
| Reads the measurement data | RMD? | <i>number_of_data</i> |

FLEX Command Programming

Quasi-static CV Measurements

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. |

FLEX Command Programming Quasi-static CV Measurements

```

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. |

FLEX Command Programming

Quasi-static CV Measurements

```

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 | [<i>chnum</i> ... [<i>,chnum</i>] ...] |
| Disables measurement units | CL | [<i>chnum</i> ... [<i>,chnum</i>] ...] |
| Sets filter on/off | [FL] | <i>onoff</i> [<i>,chnum</i> ... [<i>,chnum</i>] ...] |
| Sets measurement mode | MM | 14 |
| Selects output data | [LSVM] | <i>output_data</i> |
| Sets timing parameters | [LSTM] | <i>holdtime, delaytime</i> |
| Sets the abort function | [WM] | <i>abort</i> [<i>,post</i>] |
| Sets current search or voltage search condition | LGI or LGV | <i>chnum, mode, range, target</i> |
| Sets voltage source or current source | LSV or LSI | <i>chnum, range, start, stop, step</i> [<i>,comp</i>] |
| Sets synchronous voltage source or current source | [LSSV] or [LSSI] | <i>chnum, polarity, offset</i> [<i>,comp</i>] |
| Forces constant source | DV or DI | <i>chnum, range, output</i> [<i>,comp</i>] |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

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.

FLEX Command Programming

Linear Search Measurements

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. |

FLEX Command Programming Linear Search Measurements

```

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. |

FLEX Command Programming

Linear Search Measurements

```

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables measurement units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets filter on/off | [FL] | <i>onoff</i> [, <i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets measurement mode | MM | 15 |
| Selects output data | [BSVM] | <i>output_data</i> |
| Sets timing parameters | [BST] | <i>holdtime, delaytime</i> |
| Sets source control mode | BSM | <i>mode</i> |
| Sets current search or voltage search condition | BGI or BGV | <i>chnum, mode, condition, range, target</i> |
| Sets voltage source or current source | BSV or BSI | <i>chnum, range, start, stop</i> [, <i>comp</i>] |
| Sets synchronous voltage source or current source | [BSSV] or [BSSI] | <i>chnum, polarity, offset</i> [, <i>comp</i>] |
| Forces constant source | DV or DI | <i>chnum, range, output</i> [, <i>comp</i>] |
| Executes measurement | XE | |
| Reads measurement data | RMD? | <i>number_of_data</i> |

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.

FLEX Command Programming

Binary Search Measurements

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. |

FLEX Command Programming Binary Search Measurements

```

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. |

FLEX Command Programming

Binary Search Measurements

```

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets PGU output impedance | POR | <i>chnum,impedance</i> |
| Sets stress mode/stress time | STT | <i>hold,mode</i> [, <i>count</i> [, <i>period</i>]] ^a |
| Stress source setup | STV | <i>source,chnum,range,base,stress</i> [, <i>Icomp</i>] |
| | STI | <i>source,chnum,range,base,stress</i> [, <i>Vcomp</i>] |
| | STP | <i>source,chnum,mode,base,stress</i> [, <i>Td</i> [, <i>Tw</i> [, <i>Tl</i> [, <i>Tr</i>]]]] |
| Clears stress source setup | STC | [<i>source</i> [, <i>source</i> [, <i>source</i> [, <i>source</i>]]]] |
| Sets automatic abort condition | STM ^b | <i>abort</i> |
| Forces constant voltage | [DV] | <i>chnum,range,output</i> [, <i>Icomp</i>] |
| Forces constant current | [DI] | <i>chnum,range,output</i> [, <i>Vcomp</i>] |
| 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 ($count \times period > 10$ sec) to use the automatic abort function.

FLEX Command Programming

Stress Force

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 | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Disables Measurement Units | CL | [<i>chnum</i> ... [, <i>chnum</i>] ...] |
| Sets PGU output impedance | POR | <i>chnum,impedance</i> |
| Sets output mode | SPG | <i>chnum,mode</i> [, <i>base</i> [, <i>pulse</i> , <i>Td</i> , <i>Tw</i> , <i>Tl</i> , <i>Tt</i> , <i>Tp</i> , <i>Pc</i>]] ^a |
| Starts PGU output force | SRP | |
| Stops PGU output force | SPP | |
| Forces constant voltage | [DV] | <i>chnum,range,output</i> [, <i>Icomp</i>] |
| Forces constant current | [DI] | <i>chnum,range,output</i> [, <i>Vcomp</i>] |

- 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. |

FLEX Command Programming

Controlling PGU

```

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 <i>prog No.</i> ; <i>command</i> [... [<i>command</i>] ..] END |
| | | ST <i>prog No.</i> [<i>command</i>] : : [<i>command</i>] END |
| Scratches the program | SCR | [<i>prog No.</i>] |
| Gets a list of programs or a specific program listing | LST? | [<i>prog No.</i>] |
| Executes specified programs | DO | <i>prog No.</i> [, <i>prog No.</i> ... [<i>prog No.</i>] ...] |
| Executes programs sequentially | RU | <i>start,stop</i> |
| Pauses command execution or internal memory program execution | PA | [<i>wait time</i>] |

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.

FLEX Command Programming

Using Program Memory

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 |
| 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.

FLEX Command Programming

Using Program Memory

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. |

FLEX Command Programming Using Program Memory

```

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. |

FLEX Command Programming Using Enhanced Sweep Stop Function

```

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 the time stamp output | TSC | <i>onoff</i> |
| Resets the time stamp | TSR | |
| Returns the time data since TSR | TSQ? | |

The following commands return 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 | <i>chnum,range,output[,Icomp]</i> |
| Forces a constant current | TDI | <i>chnum,range,output[,Vcomp]</i> |
| Measures the current | TTI | <i>chnum,range</i> |
| Measures the voltage | TTV | <i>chnum,range</i> |
| Measures the current and reads the data | TTI? | <i>chnum,range</i> |
| Measures the voltage and reads the data | TTV? | <i>chnum,range</i> |

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/TTI?/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). |

FLEX Command Programming

Reading Time Stamp Data

```

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. |

FLEX Command Programming

Reading Time Stamp Data

```

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 | <i>file_name,mode</i> |
| Closes the file | CLOSE | |
| Writes data | WR | <i>data</i> (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"
```

FLEX Command Programming

Reading and Writing Data to a File

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 (,). |

FLEX Command Programming Reading and Writing Data to a File

```

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). |

FLEX Command Programming

Reading and Writing Data to a File

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. |

FLEX Command Programming

Reading and Writing Data to a File

```

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.

FLEX Command Programming

Reading and Writing Data to a File

```

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. |

FLEX Command Programming Reading and Writing Data to a File

```

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 | <i>data</i> (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\$. |

FLEX Command Programming

Printing Data

```

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

```

FLEX Command Programming

Reading Binary Output Data

```

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=SHIFT(D5,-3)*8+SHIFT(D6,5)
800     !
810         Count=SHIFT(D5,5)
820         Count=Count+D4*8
830         Count=Count+D3*8*256.
840         Count=Count+SHIFT(D2,-10)*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. |

FLEX Command Programming

Reading Binary Output 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.

FLEX Command Programming Using the US42 Control Mode

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 the operation status
- Improving the measurement speed

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 automatic zero offset function of the internal A/D converter (ADC) by using the AZ command. This reduces the integration time to approximately half, if the integration time is set to approximately 10 msec or more.

NOTE

The internal ADC auto zero offset 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.

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.

Running 4145A/B Program Directly on 4155C/4156C Considerations about Differences

- 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.

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`.

ASP-Like IBASIC Programming

Creating ASP-like IBASIC Programs

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 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 NEXT I
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 |
|------------------|-----------|--|
| <i>file_name</i> | 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""")
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 |
|------------------|-----------|---|
| <i>file_name</i> | 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""")
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 |
|-----------------------------|--------|---|
| <i>data_variable_name</i> | 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. |
| <i>ibasic_variable_name</i> | string | name of numeric variable or numeric array of IBASIC program. <i>ibasic_variable_name</i> is not case sensitive. |

Example

```
EXECUTE ("READDATAVAR 'V1',V")  
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 |
|-----------------------------|---------|--|
| <i>user_variable_name</i> | string | user variable name that you want to define. You must enclose the name with single quotes or double-double quotes. |
| <i>no_of_points</i> | numeric | number of data for the user variable. |
| <i>ibasic_variable_name</i> | string | name of numeric variable or numeric array of IBASIC program. The data in this variable will be transferred to the user variable. |
| <i>unit</i> | 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
```