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HP 75000 SERIES B

Installing an HP E1306A Command Module-Based System

Configuration Guide

HEWLETT® PACKARD

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Edition 1 (Part Number E1303-90000) . . . . . October 1994

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Instruction manual symbol affixed to product. Indicates that the user must refer to the manual for specific Warning or Caution information to avoid personal injury or damage to the product.

Indicates the field wiring terminal that must be connected to earth ground before operating the equipment—protects against electrical shock in case of fault.

OR Frame or chassis ground terminal—typically connects to the equipment's metal frame.

Alternating current (AC).

Direct current (DC).

Indicates hazardous voltages.

WARNING Calls attention to a procedure, practice, or condition that could cause bodily injury or death.

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DO NOT operate the product in an explosive atmosphere or in the presence of flammable gases or fumes.

For continued protection against fire, replace the line fuse(s) only with fuse(s) of the same voltage and current rating and type.
DO NOT use repaired fuses or short-circuited fuse holders.

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You can help us improve our manuals by sharing your comments and suggestions. Please complete this questionnaire after becoming familiar with the manual and then return it to us. **In appreciation of your time, we will enter your name in a quarterly drawing for a Hewlett-Packard Palmtop Personal Computer.**

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• The manual is clearly written.	O	O	O	O	O
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Contents

Warnings and Cautions vii

Chapter 1 Installing the System

Should I Use this Guide or HP VIC? 1-1
Installation Steps 1-2
Step 1: Install Correct Fuse for Your Line Voltage 1-3
Step 2: Rack Mount the Mainframe (Optional) 1-4
Step 3: Install Command Module 1-5
Step 4: Determine Instrument Configurations 1-6
Step 5: Set Plug-In Module Logical Addresses 1-9
Step 6: Install Plug-In Modules 1-12
Step 7: Connect Bus Cables (Multiple Module Instruments Only) 1-13
Step 8: Connect Interface Cables 1-14
Step 9: Apply AC Power 1-16
Step 10: Connect Standby DC Power (Optional) 1-17
Step 11: Download Device Drivers 1-18
Step 12: Verify Operation 1-19
Where to go Next 1-22

Chapter 2 Sending SCPI Commands

Verification and Example Programs 2-1
Primary and Secondary HP-IB Addressing 2-1
Using Visual BASIC and HP SICL 2-2
What's Needed 2-2
How to Run a Program 2-2
Sending SCPI Commands and Receiving Data 2-2
Program Example 2-4
Using C/C++ and HP SICL 2-5
What's Needed 2-5
How to Run a Program 2-5
Sending SCPI Commands and Receiving Data 2-6
Program Example to Send and Read Unformatted Data 2-8
Example to Read Formatted Data 2-9
Example to Send and Read Formatted Data 2-9
Using C and the HP-IB Command Library 2-10
Supported C Programs 2-10
Executing a Program 2-10
Compiling a Program 2-11
Sending SCPI Commands 2-11
Receiving Data 2-11
Program Example 2-12
Using HP BASIC 2-13
Sending SCPI Commands 2-13

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Receiving Data 2-13
Program Example 2-14
Using a Terminal 2-15
Connecting the Terminal 2-15
Sending SCPI Commands 2-15

Appendix A In Case Of Difficulty

No Communication Between Command Module And Computer A-1
Start-Up Errors and Messages A-2
Error: 1: Failed Device A-2
Error: 3: Config warning. Device driver not found A-3
Error 10: Config error 10. Insufficient system memory A-3
Error 11: Config error 11. Invalid instrument address A-3
Error 13: Config error 13. Logical address or IACK switch set wrong A-3
System Errors and Messages A-3
Reading the Error Queue A-3
Error Types A-4
System Error Message Listing A-4

Appendix B Debugging VXI SCPI Programs

Introduction B-1
Steps To Debug Programs B-1
Step 1: Verify Instrument Communication B-1
Step 2: Reset Each instrument at the Start of the Program B-3
Step 3: Query the Instruments for Errors B-4
Step 4: Query All Command Parameter Settings that are Set B-4
Step 5: Check the Program is Trying to Enter the Same Amount B-5
Step 6: Check the Instrument's Arm/Trigger Subsystem B-5
Step 7: Check that Coupled Commands are Sent as a Group B-6
Step 8: Check for Command Synchronization B-6
Automating the Debugging Steps B-7
RN13_RMB Program B-7
Using other Program Languages B-7
Using the Program B-7
Program Description B-8
Program Theory B-9

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Warnings and Cautions

WARNING **SHOCK HAZARD. Only service-trained personnel who are aware of the hazards involved should install, remove, or configure the system. Before you perform any procedures in this guide, disconnect AC power and field wiring from the mainframe.**

Caution **Do not install modules into the mainframe with power applied. Doing so may damage the modules and the mainframe.**

Caution **STATIC ELECTRICITY. Static electricity is a major cause of component failure. To prevent damage to the electrical components in the mainframe and plug-in modules, observe anti-static techniques whenever installing a module into the mainframe.**

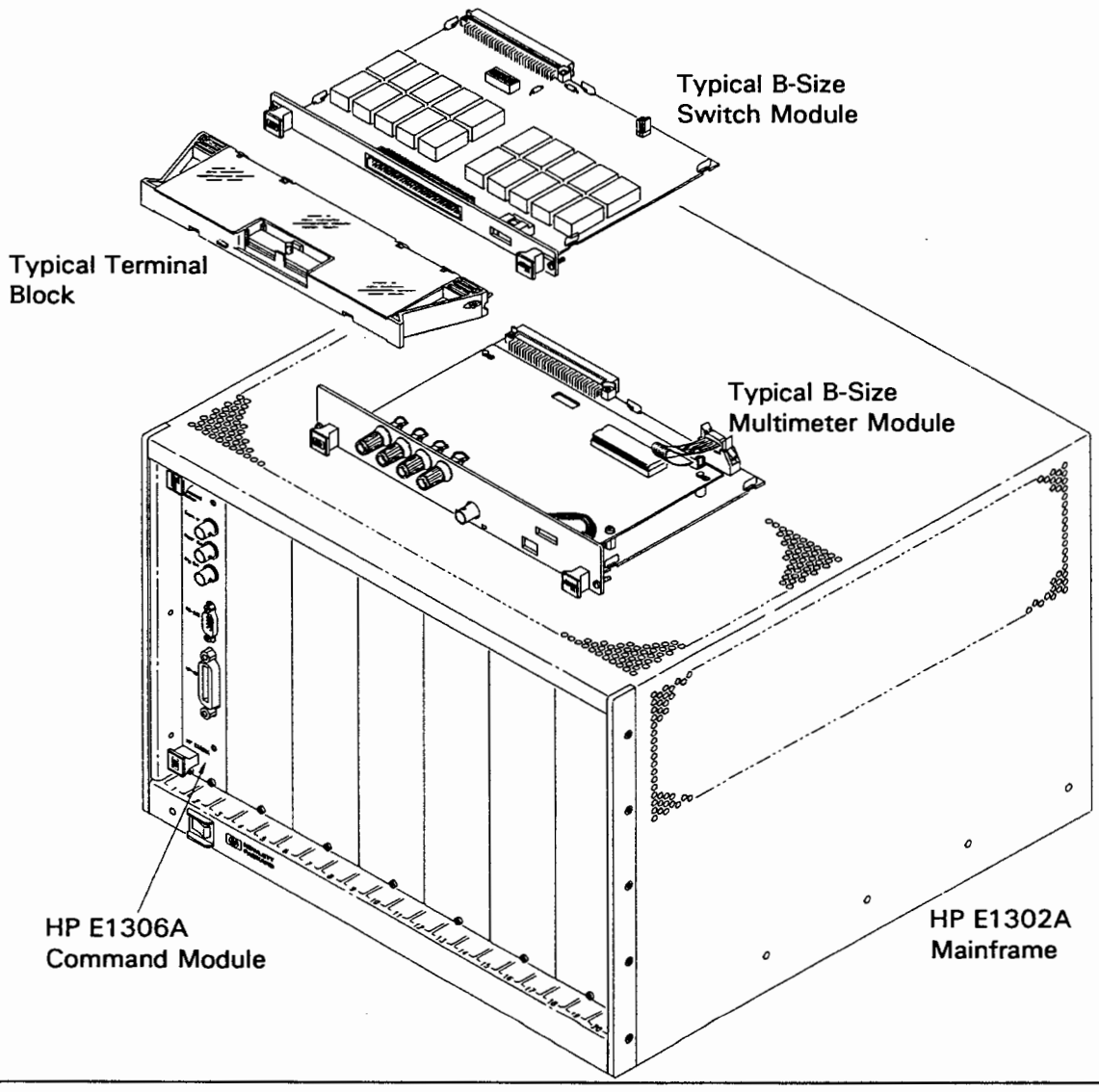
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Chapter 1
Installing the System

This chapter describes how to install the HP E1306A Command Module and B-size plug-in modules into a B-Size VME/VXI mainframe. The mainframe referenced in the examples is an HP E1302A. If you are using a different mainframe, refer to that mainframe's documentation for specific mainframe details.

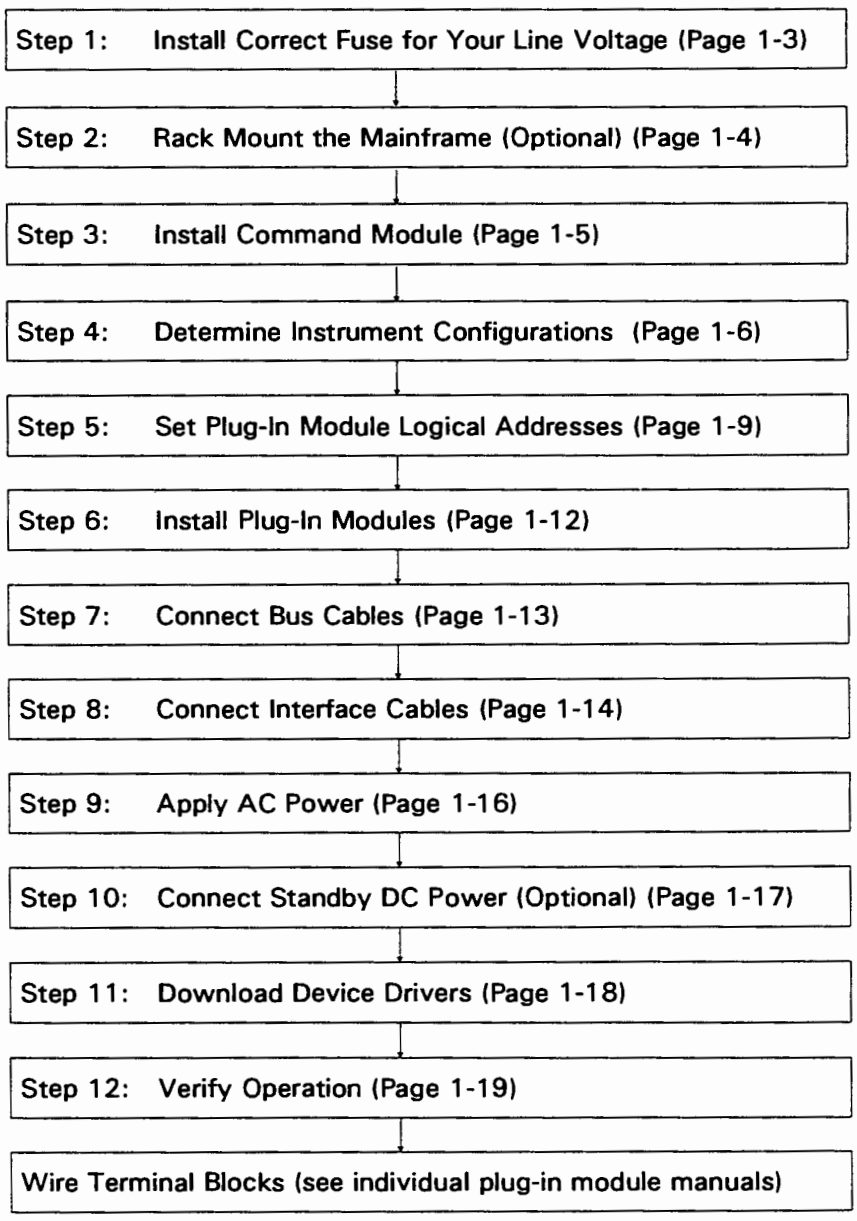
Should I Use this Guide or HP VIC?

In an effort to make installation of your B-size VME/VXI system as easy as possible, we have included HP VIC (HP VME/VXI Installation Consultant) with the Command Module. HP VIC is a Microsoft® Windows 3.1™ compatible program that helps you configure and install your system. If you are using an external Personal Computer to control the system, we recommend that you configure your system using HP VIC instead of this Configuration Guide. For all other computers, use this Configuration Guide.



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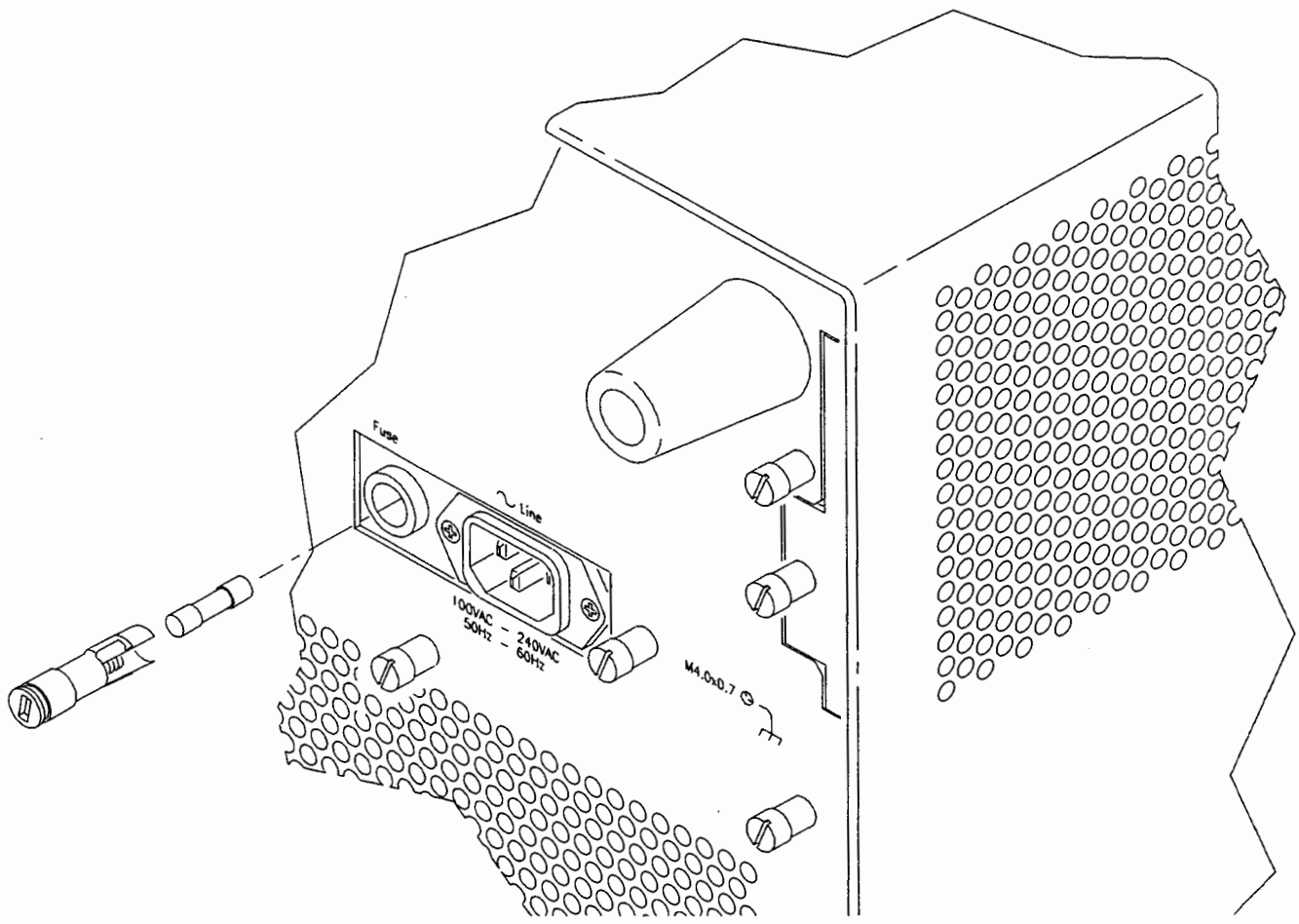
Installation Steps



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Step 1: Install Correct Fuse for Your Line Voltage

WARNING **SHOCK HAZARD. Disconnect power from the mainframe before doing any installation steps.**



For the HP E1302A Mainframe:

For 230VAC operation, install 4A fuse

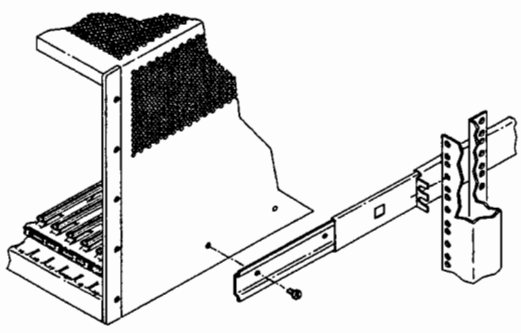
For 115VAC operation, install 8A time delay fuse

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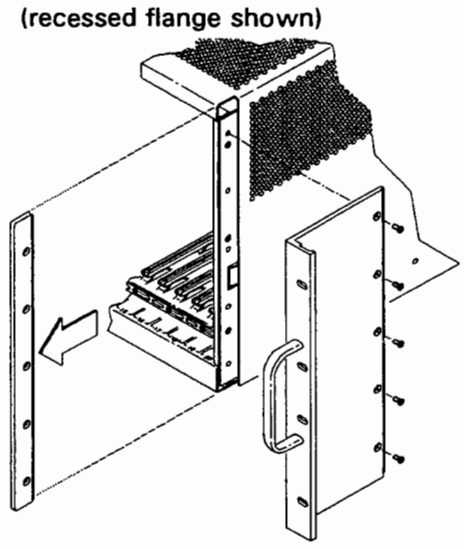
Step 2: Rack Mount the Mainframe (Optional)

Note Simplified rack mount installation steps are shown here. Refer to the instructions provided with the rack mount kits for specific details.

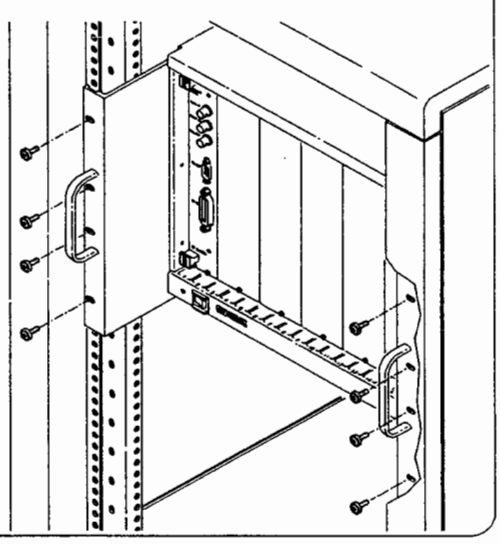
A Install slides onto mainframe and rack



B Install rack mount hardware (recessed flange shown)



C Secure mainframe to rack

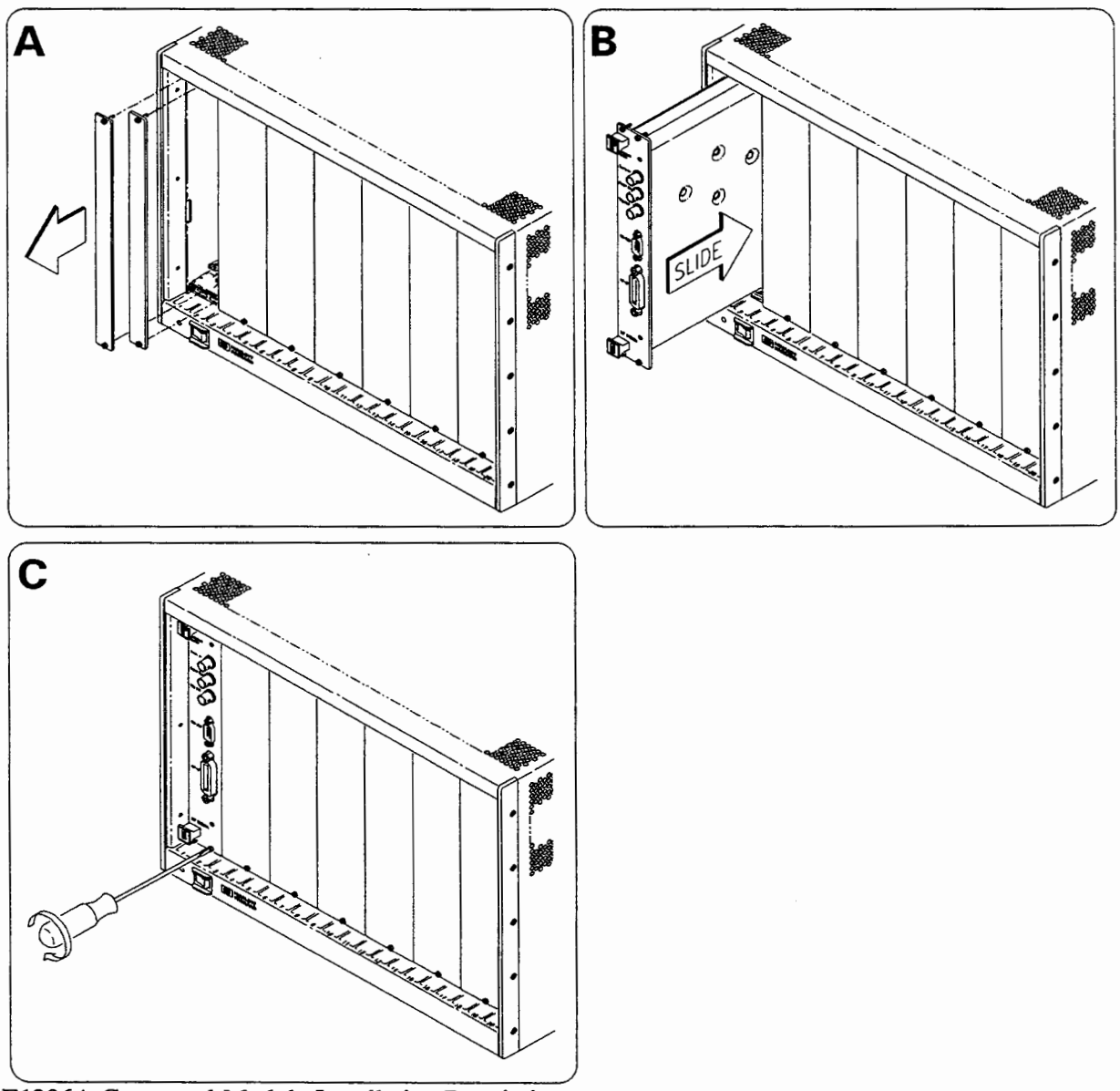


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Step 3: Install Command Module

Warning **SHOCK HAZARD. Secure Command Module tightly to the mainframe.**

Caution **To prevent equipment damage, DISCONNECT the mainframe's power before installing any module into the mainframe.**



HP E1306A Command Module Installation Restrictions:

- The Command Module must be installed in slots 1 and 2.
- The Command Module must be the Resource Manager and there can be no other bus managers in the mainframe.
- The Command Module cannot be used in the HP E1300A/E1301A Mainframe.

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Step 4: Determine Instrument Configurations

In this step, you determine the instrument configurations that best suit your application. You will create the instruments in the next step "Step 5: Set Plug-In Module Logical Addresses."

A module can be set up as a single module instrument or as part of a multiple module instrument. For example, many HP plug-in modules can be configured as part of a multiple module Scanning Multimeter or Switchbox instrument. A single module instrument is programmed and operated independently from the other modules in the mainframe. Multiple module instruments are programmed and operated together as one instrument. You designate whether a module is a single module instrument or part of a multiple module instrument by how you set its logical address switch.

Single Module Instruments

To create a single module instrument, simply set the module's logical address to a multiple of 8 (such as 8, 16, 24 ...256). In most cases, you can use the factory set logical address—provided no other modules are set to the same address. Single module instruments are recommended when you want to program the module independently and the module will have little or no interaction with other switching modules. Figure 1-1 is a block diagram showing four single module instruments and their logical addresses.

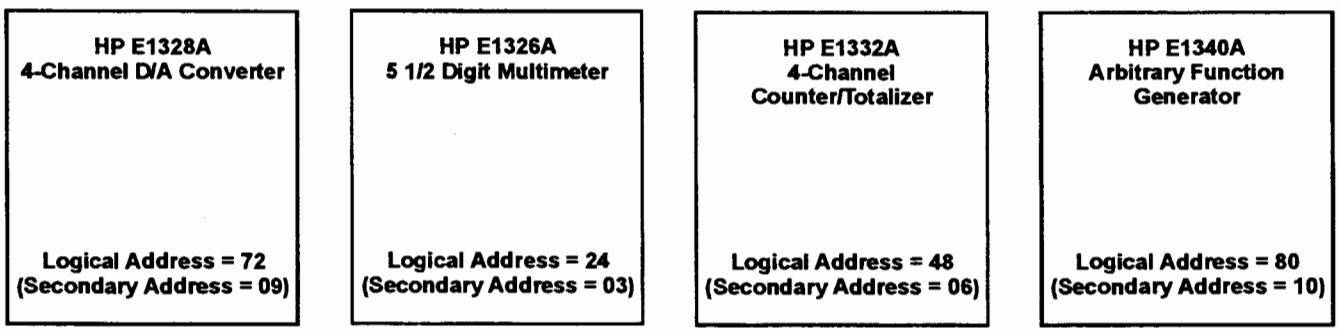


Figure 1-1. Single Module Instruments Block Diagram

Notice that each instrument has an HP-IB* secondary address which is its logical address divided by eight (for example, 72/8 = 09). This secondary address is used when programming the instruments.

*HP-IB is Hewlett-Packard's implementation of IEEE Standard 488.1-1978 (GP-IB).

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Scanning Multimeter Instrument

The Scanning Multimeter instrument consists of an HP E1326B Multimeter and one or more multiplexer modules. In this configuration, the multiplexer modules scan measurement channels and feed the signal through the analog bus to the multimeter where the measurements take place. Programming is simplified because one command controls both the measurement type and the channels to be scanned. The Scanning Multimeter configuration is recommended when:

- Using the multimeter to make measurements on a series of channels (scanned channels).
- The fastest execution speed for scanned measurements is needed.
- Only one channel closure at a time is needed.

To create a Scanning Multimeter instrument, you set the multimeter module's logical address to a multiple of eight and assign the multiplexer modules successive logical addresses. You then connect the Analog Bus cables between all modules (this is shown in detail later in Step 7).

For example, as shown in Figure 1-2, if the multimeter's logical address is 24, the multiplexers would be 25, 26, and so on. In this example, the Scanning Multimeter will be programmed at HP-IB secondary address 03. This address is derived by dividing the multimeter's logical address by eight (24/8 = 03).

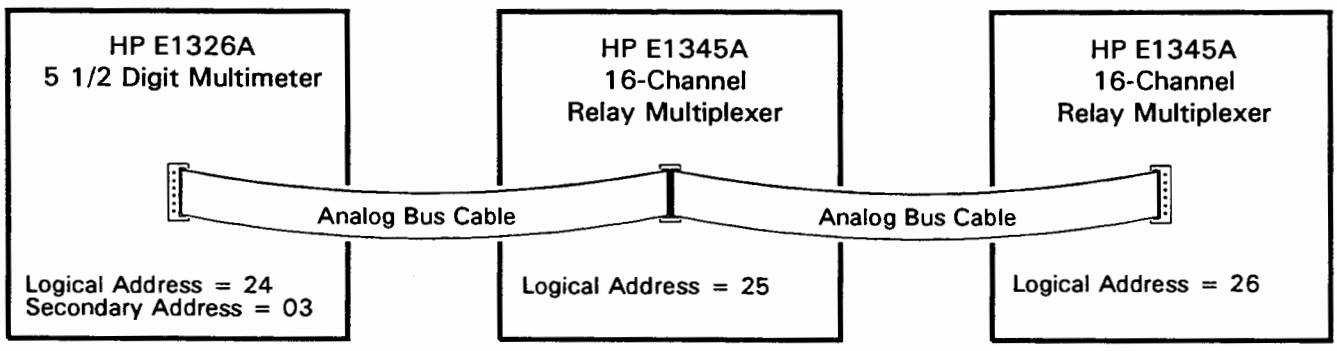


Figure 1-2. Scanning Multimeter Instrument Block Diagram

These multiplexer modules can be part of a Scanning Multimeter:

E1343A 16-Channel High Voltage Multiplexer
E1345A 16-Channel Relay Multiplexer
E1346A 48-Channel Single Ended Relay Multiplexer
E1347A 16-Channel Thermocouple Relay Multiplexer
E1351A 16-Channel FET Multiplexer
E1352A 32-Channel Single-Ended FET Multiplexer
E1353A 16-Channel Thermocouple FET Multiplexer
E1355A 8-Channel 120Ω Strain Relay Multiplexer
E1356A 8-Channel 350Ω Strain Relay Multiplexer
E1357A 8-Channel 120Ω Strain FET Multiplexer
E1358A 8-Channel 350Ω Strain FET Multiplexer

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Switchbox Instrument

The Switchbox instrument is composed of one or more switch modules. The single module Switchbox behaves as an independent instrument as described earlier. When using the multiple module Switchbox, all switch modules are programmed together and behave as if they are one instrument. The multiple module Switchbox configuration is recommended when you need to:

- Simplify the programming of multiple switch modules.
- Group multiplexers together to create a larger multiplexer.
- Make scanned measurements but are **not** using the HP E1326B Multimeter (if you **are** using the HP E1326B, use the Scanning Multimeter configuration).
- Close channels on more than one module simultaneously.

To create a multiple module Switchbox, set one switch module's logical address to a multiple of eight and assign the other switch modules successive logical addresses. If applicable, you then connect the Analog Bus cables between all modules (this is shown in detail later in Step 7).

Figure 1-3 is a block diagram example of a Switchbox instrument containing three multiplexers. In this example, one multiplexer has a logical address of 112, the other multiplexers have successive logical addresses of 113 and 114. The multiplexers are linked together using the Analog Bus to form a larger (48-channel) multiplexer. In this example, the Switchbox will be programmed at HP-IB secondary address 14. This address is derived by dividing the first multiplexer's logical address by eight (112/8 = 14).

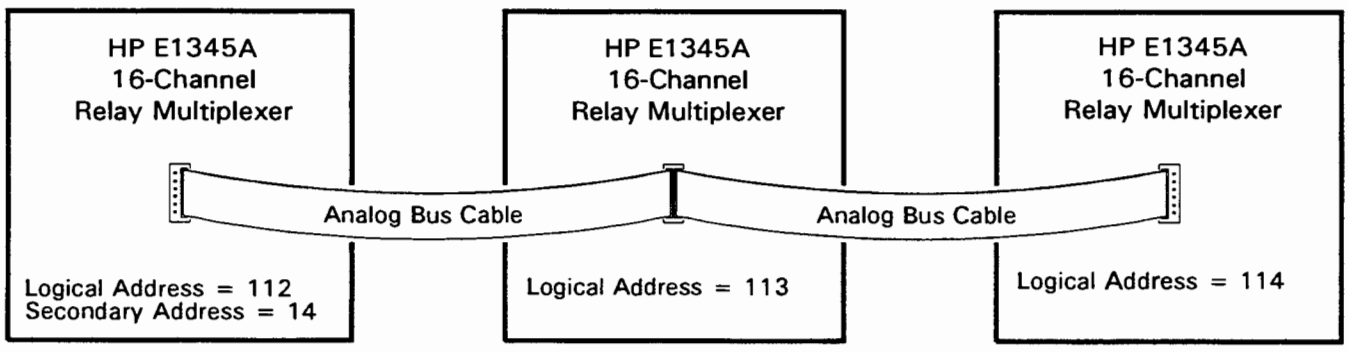


Figure 1-3. Switchbox Instrument Block Diagram

These modules can be used to form a switchbox:

E1343A 16-Ch. High Voltage Multiplexer
E1344A 16-Ch Thermocouple High Volt Multiplexer
E1345A 16-Ch. Relay Multiplexer
E1346A 48-Ch. Single Ended Relay Multiplexer
E1347A 16-Ch. Thermocouple Relay Multiplexer
E1351A 16-Ch. FET Multiplexer
E1352A 32-Ch. Single-Ended FET Multiplexer
E1353A 16-Ch. Thermocouple FET Multiplexer
E1355A 8-Ch. 120W Strain Relay Multiplexer
E1356A 8-Ch. 350W Strain Relay Multiplexer
E1357A 8-Ch. 120W Strain FET Multiplexer
E1358A 8-Ch. 350W Strain FET Multiplexer
E1361A 4 x 4 Relay Matrix
E1364A 16-Ch. Form C Switch
E1366A 50W RF Multiplexer (2 x 4:1)
E1367A 75W RF Multiplexer (2 x 4:1)
E1368A 18 GHz Microwave Switch
E1369A Microwave Switch Driver
E1370A Switch Microwave/Attenuator Driver

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Step 5: Set Plug-In Module Logical Addresses

As shown in Figure 1-4, a logical address switch contains eight individual switches. To determine the logical address, add together the decimal values of the switches that are set (position 1 = set, 0 = not set). For example, in Figure 1-4 , switches 4, 5, and 6 are set, the other switches are not set. The logical address is the sum of the decimal values of the set switches: 16 + 32 + 64 = 112.

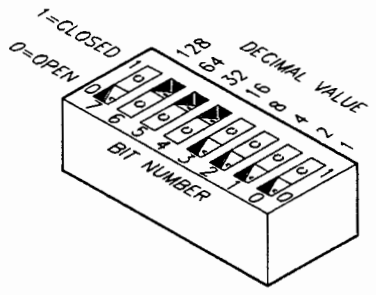


Figure 1-4. Logical Address Switch

Guidelines for Setting Logical Addresses

- Each plug-in module must have a unique logical address. If you have modules with the same factory-set logical address, you must change some logical addresses so that each module has a different address.

- Each instrument, whether single or multiple module, must have one module assigned as an **instrument identifier**. The instrument identifier is the module with its logical address set to a multiple of 8, such as 8, 16, or 24. An instrument's **secondary address** (used to program the module from HP-IB) is derived by dividing the instrument identifier by 8. For example, a logical address of 24 is a secondary address of 03.

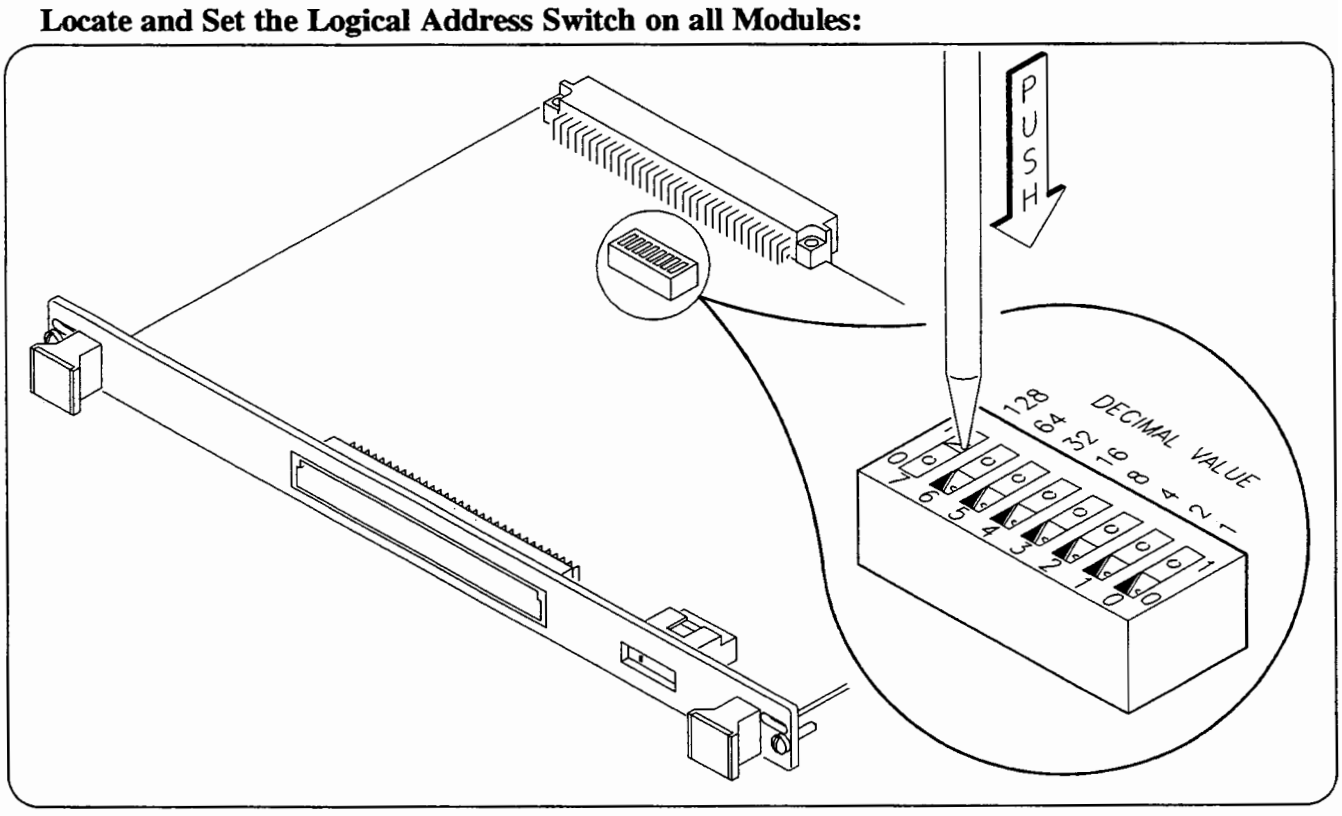
- Examples showing the settings for a single module instrument, a multiple module Switchbox instrument, and a Scanning Multimeter instrument are shown on the following pages.

- A plug-in module with a logical address that is not a multiple of 8, or that is not part of a Scanning Multimeter or Switchbox instrument, is an unassigned module. Such modules must be programmed at the register level, rather than with SCPI commands.

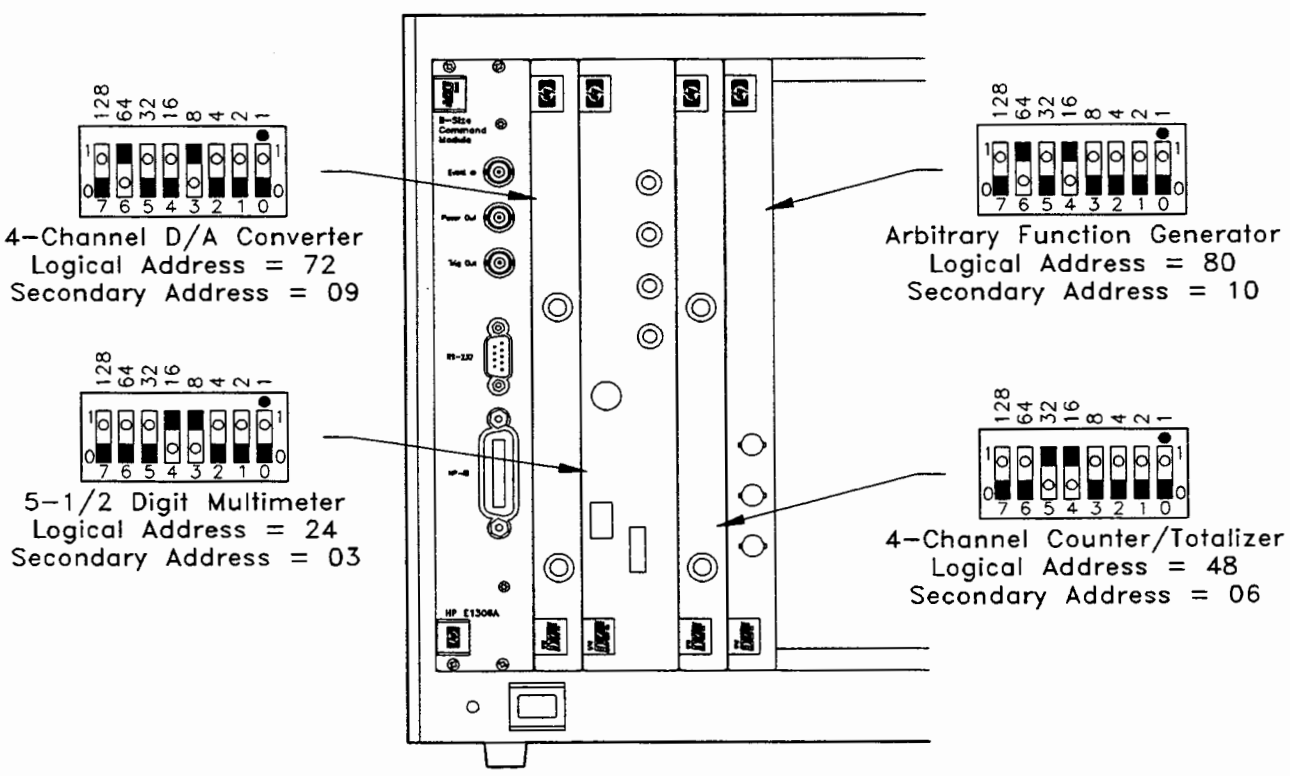
- Refer to the individual plug-in module manuals for logical address switch locations and the types of switches used (slide, rocker, etc.)

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Locate and Set the Logical Address Switch on all Modules:

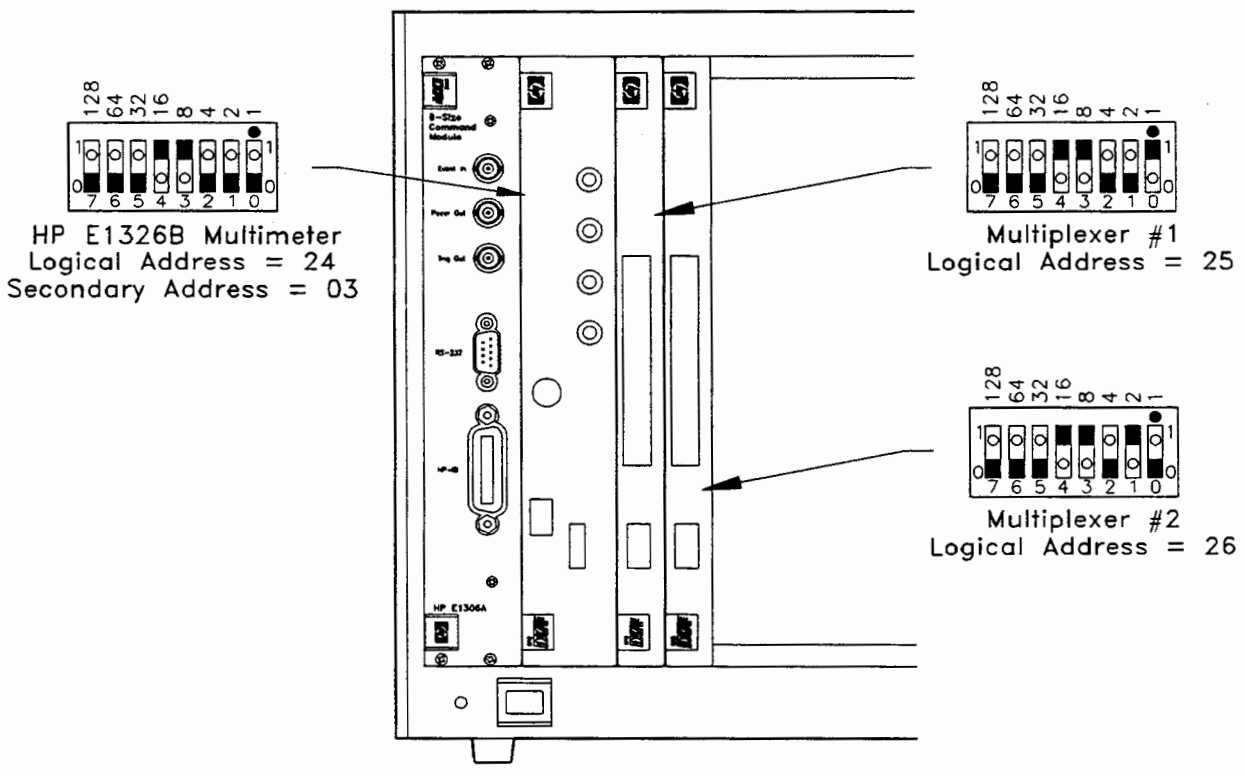


Example 1-1. Single Module Instruments:

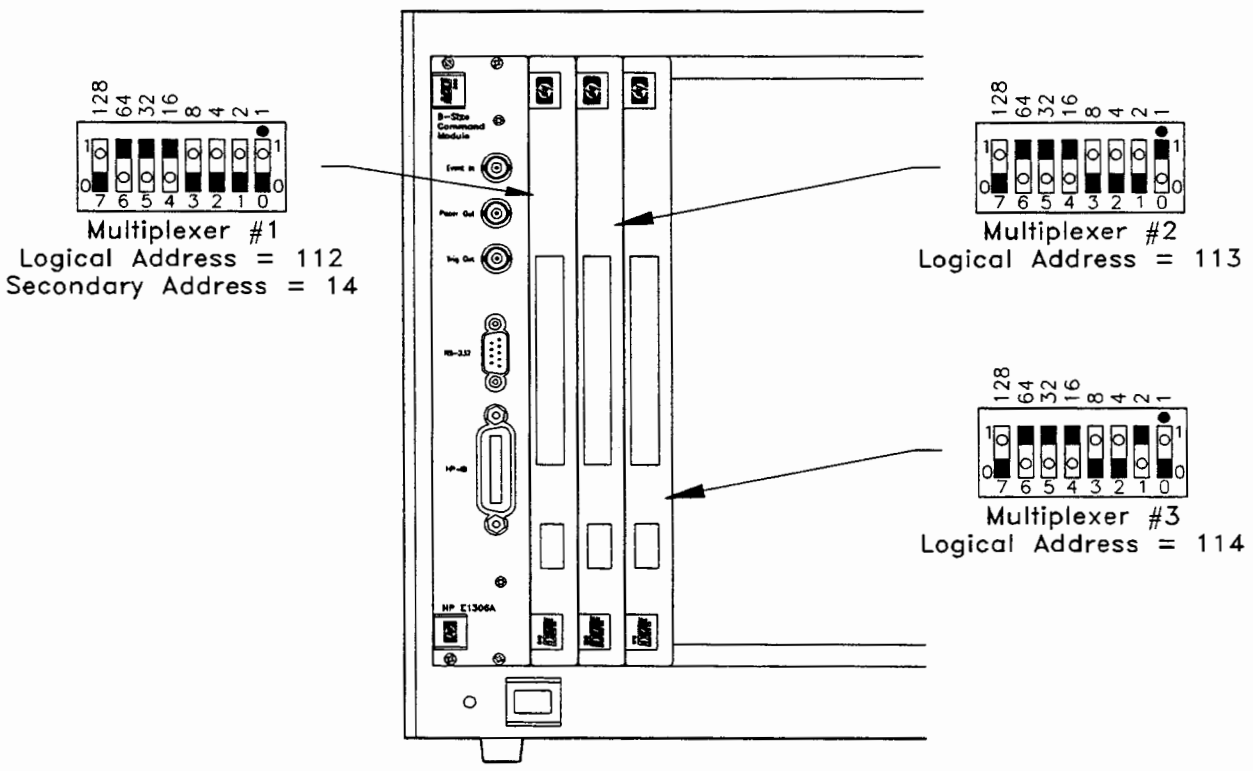


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Example 1-2. Scanning Multimeter Instrument:



Example 1-3. Multiple Module Switchbox Instrument:

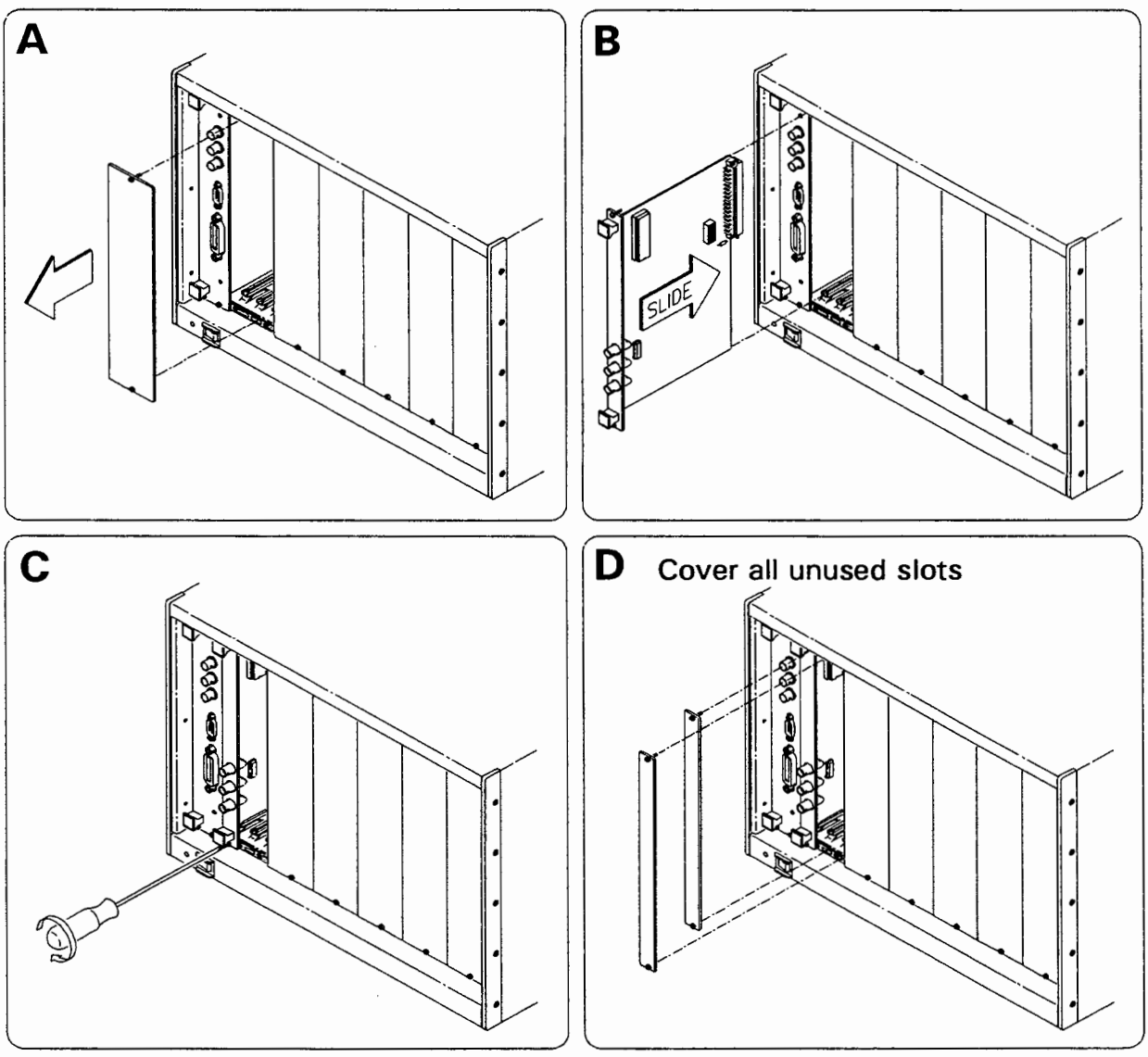


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Step 6: Install Plug-In Modules

Warning **SHOCK HAZARD. Secure modules tightly to the mainframe and cover all unused slots.**

Caution **To prevent equipment damage, DISCONNECT the mainframe's power before installing any module into the mainframe.**

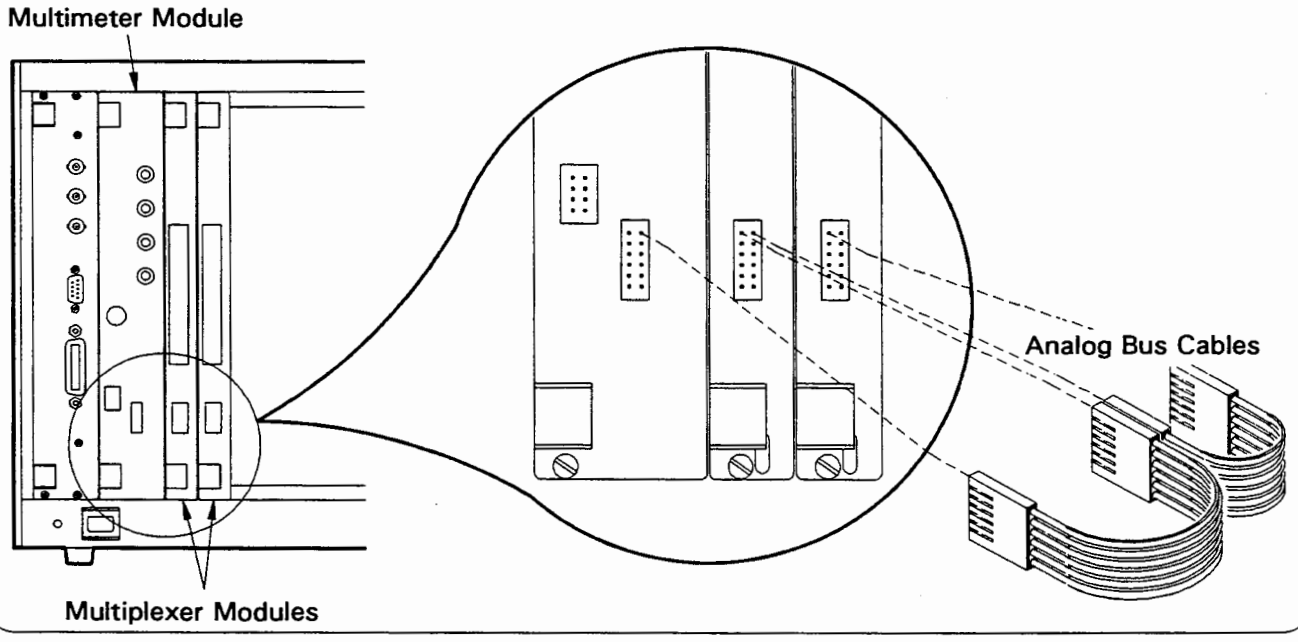


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Step 7: Connect Bus Cables (Multiple Module Instruments Only)

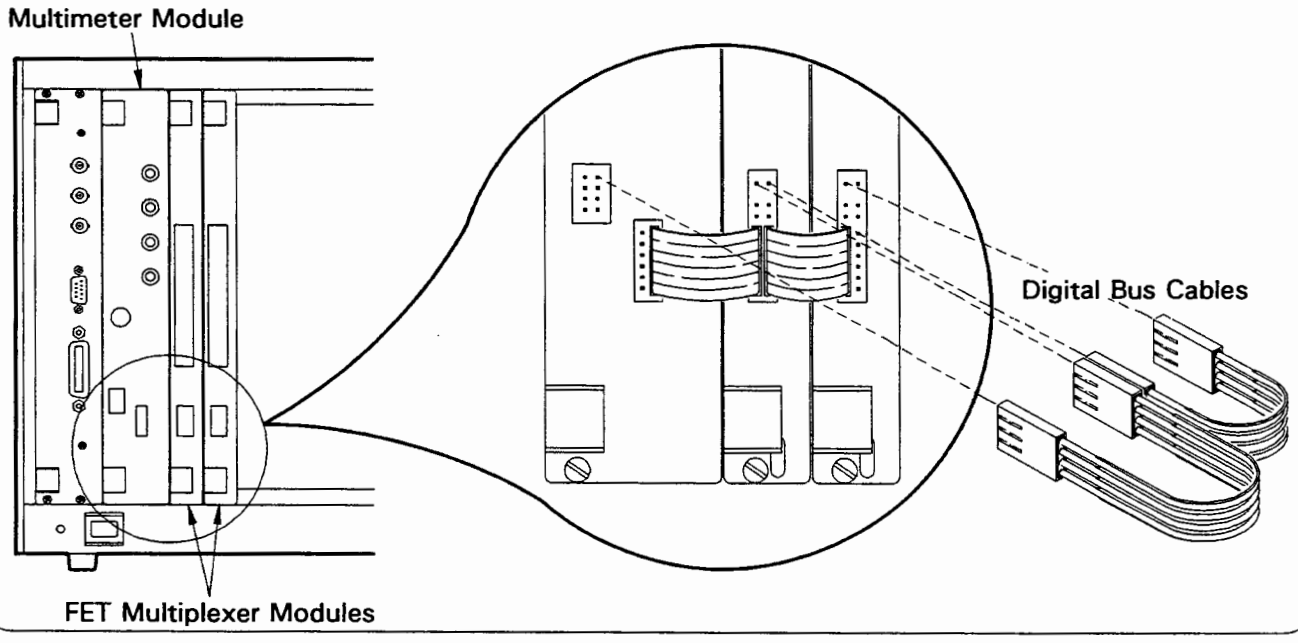
The **Analog Bus** creates an analog signal path between modules. The Analog Bus cables are **always** used in the Scanning Multimeter instrument and can also be used to link multiplexers in a Switchbox instrument.

Step 7A: Connect Analog Bus Cables



The **Digital Bus** ensures maximum scanning rates when using a Scanning Multimeter containing **FET** type multiplexers (HP E1351A, E1352A, E1353A, E1357A or E1358A). The Digital Bus is **not** used with **relay** type multiplexers such as the HP E1345A.

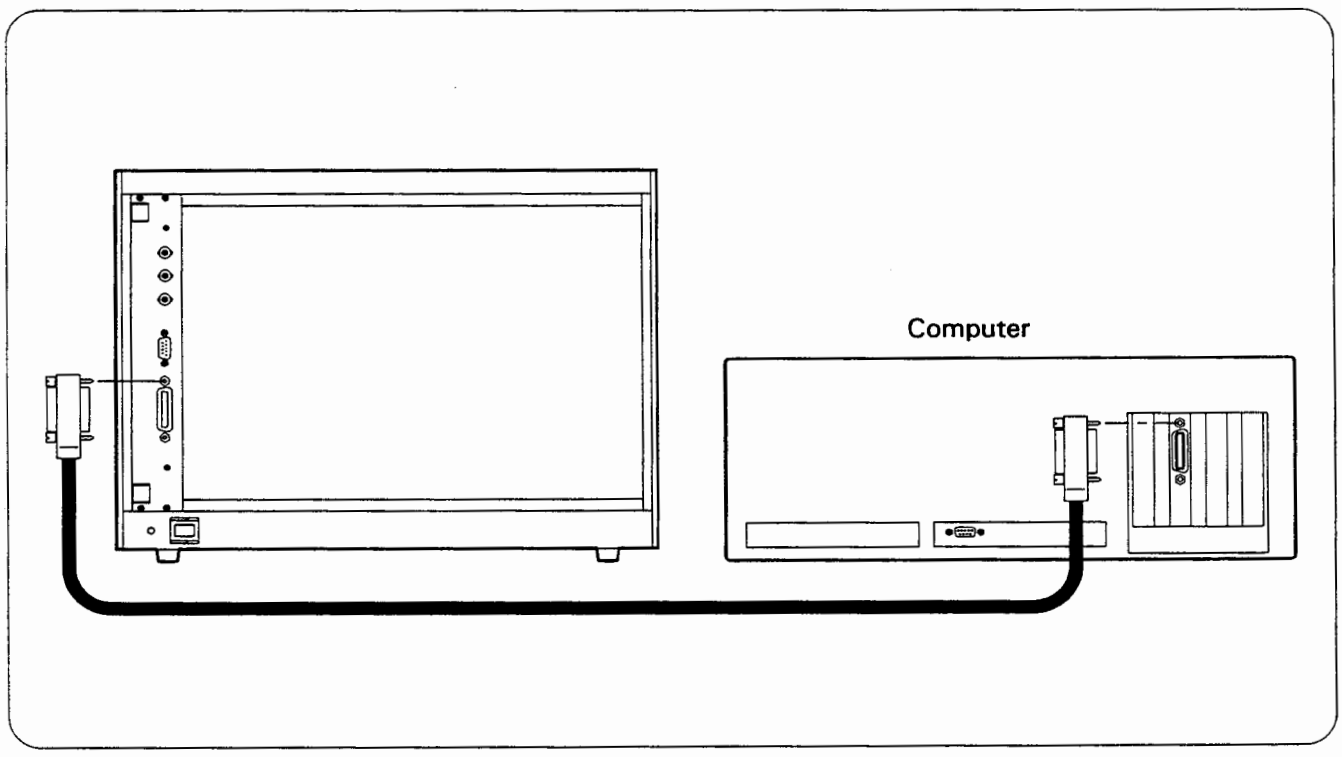
Step 7B: Connect Digital Bus Cables (FET Multiplexers Only)



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Step 8: Connect Interface Cables

Connect the HP-IB Cable to External Controller/HP-IB Peripherals:

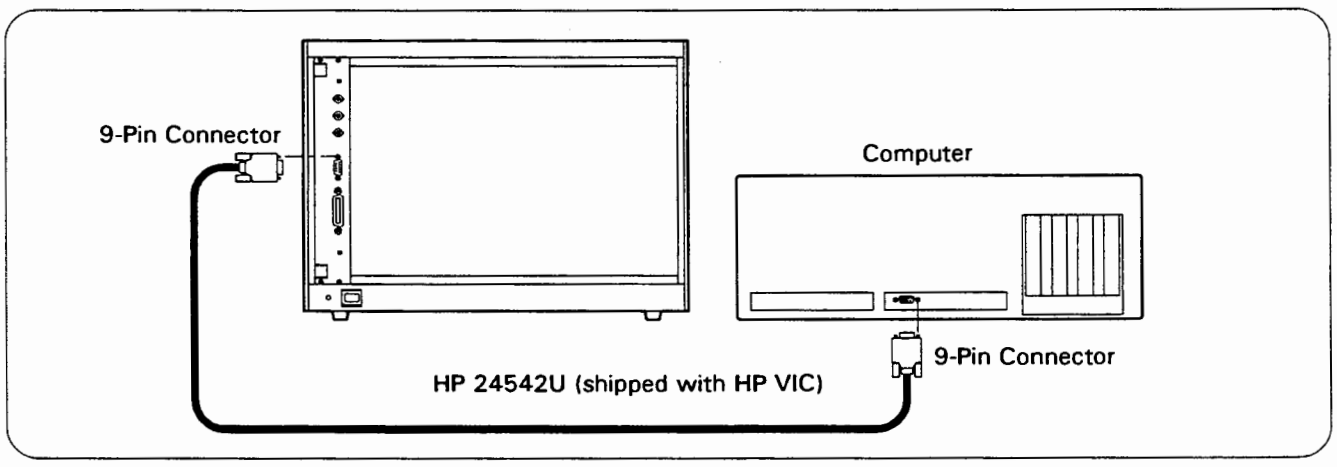


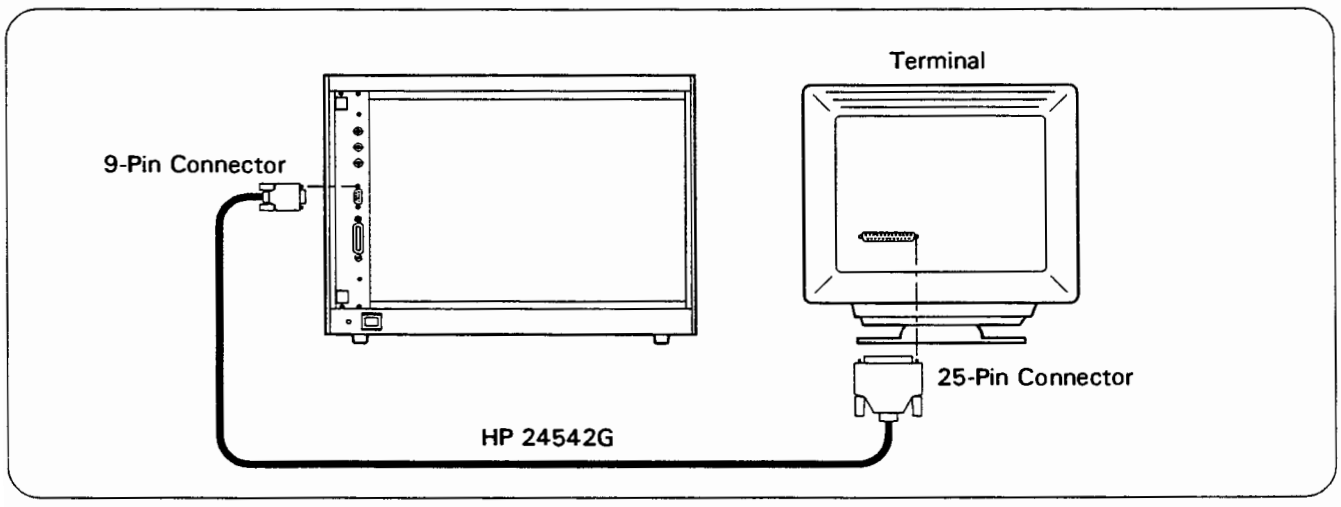
The available HP-IB cables and their HP part numbers are:

0.5 meter . . . . . HP 10833D
1 meter . . . . . HP 10833A
2 meter . . . . . HP 10833B
4 meter . . . . . HP 10833C

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Connect the RS-232 Cable to a Computer or Terminal:





Set your computer or terminal communications protocol to:

- Baud Rate — 9600
- Parity/Data Bit — None/8
- Pacing — XON/XOFF
- Enq/Ack — Off
- 1 Stop bit

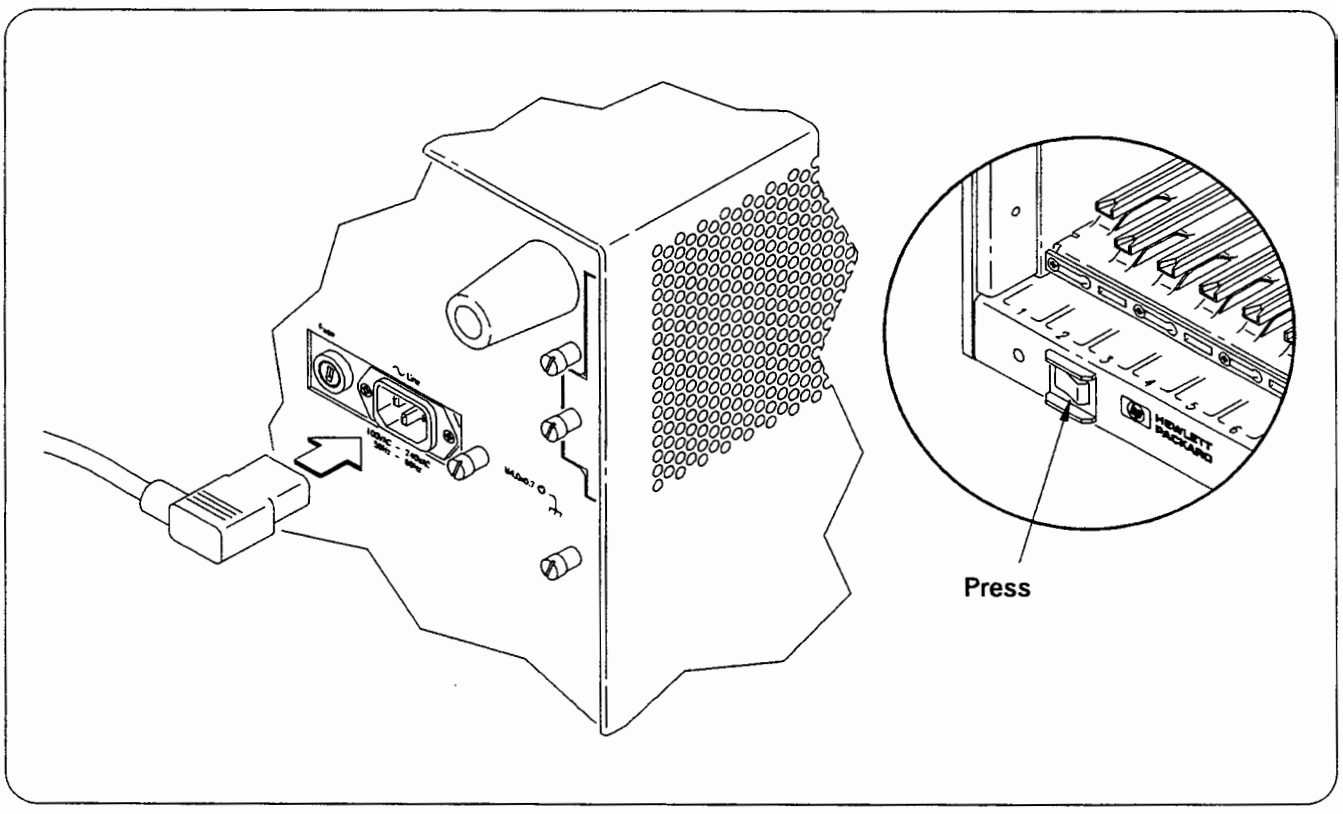
Notes

1. The RS-232 cable will be necessary if you need to download device drivers (Step 11).
2. For longer distances, you may need a custom built cable. A wiring diagram for 9-pin to 9-pin and 9-pin to 25-pin cables is shown in Appendix C of the HP E1306A Command Module User's Manual.

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Step 9: Apply AC Power

Warning **The power cord must be plugged into an approved three-contact electrical outlet. The outlet must have its own ground connector connected to an electrical ground.**

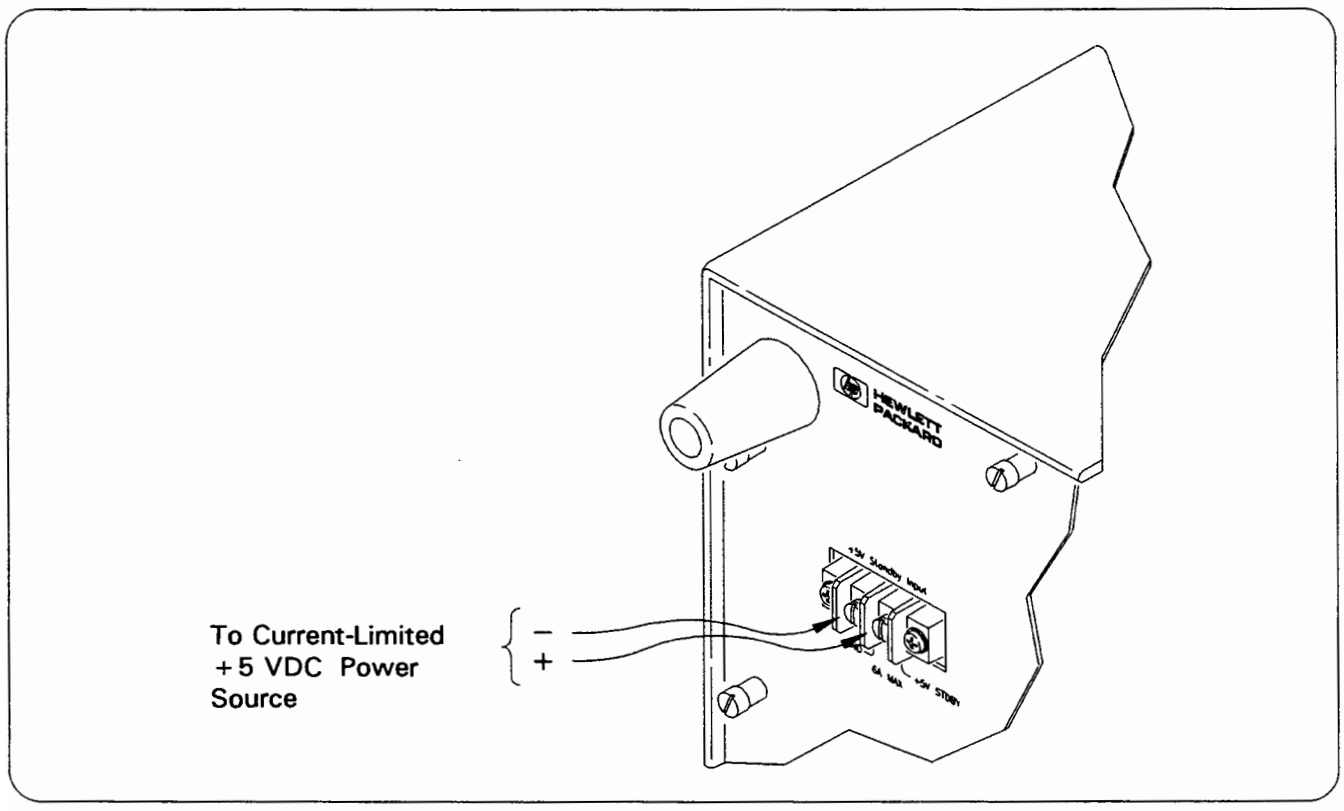


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Step 10: Connect Standby DC Power (Optional)

Many mainframes have a +5VDC Standby input which is connected to the +5VSTDBY line on the backplane J1 connector. You can connect an external battery or power supply to this input to sustain memory, clocks, and so on when AC power to the mainframe is cut-off. (Note that the HP E1306A Command Module also has a built-in battery for sustaining its non-volatile memory.) The HP E1302A mainframe's +5VDC Standby input is shown below.

Caution: **The HP E1302A's +5VDC Standby input IS NOT protected from an over-current situation. To prevent equipment damage, use a power source that is current-limited (3A max.) or install a 3A fast-blow fuse in series in the +5V line.**



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Step 11: Download Device Drivers

If your instrument is **not** listed in the table below, you must download the device driver so that the Command Module can interpret the instrument's SCPI (Standard Commands for Programmable Instruments) commands. Device drivers enable register-based modules to be programmed using SCPI commands.

Factory Installed Device Drivers:

Register-Based Device Model Number	Device Description
HP E1326B	5 1/2-Digit Multimeter
HP E1328A	4-Channel D/A Converter
HP E1330B	Quad 8-Bit Digital Input/Output
HP E1332A	4-Channel Counter/Totalizer
HP E1333A	3-Channel Universal Counter
Most Switch Modules	Multiplexers, Matrix, General Purpose

Drivers that are not factory-installed are on a disk shipped with the module. Instructions for downloading the drivers are included in the Downloading Device Drivers Installation Note. If a driver is not installed, the Command Module will report the following message to an external terminal at the end of the power-on sequence:

WARNING: DEVICE DRIVER NOT FOUND

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Step 12: Verify Operation

This step verifies Command Module operation by:

- Checking for start-up errors
- Checking for system errors
- Checking/Setting the System Time
- Checking/Setting System Date
- Determining the Installed Instruments

Use Step 12A to verify using a program supplied on the "Verification and Example Program Disk", or use Step 12B to verify using other programs.

Note If errors are noted or your computer is unable to communicate with the mainframe, go to Appendix A "In Case Of Difficulty" for troubleshooting information.

Step 12A: Verify Using The VERF_*XXX* Program

Use the program called "VERF_*XXX*" (the "XXX" identifies program type) to verify the Command Module operation. There are two programs for Windows, three for DOS. and one for HP computers with HP BASIC. The programs can be found on the "Verification and Example Programs" disks that came with the Command Module. Included on the disks are both the executable files and source codes (to allow customizing the programs).

Note To verify Command Module operation using a program and language other than those provided, go to page 1-20.

Programs for DOS

- VERF_CC.EXE - this program requires an HP 82335 HP-IB Interface Card. The program was written in the C language using the HP-IB Command Library, which comes with the HP 82335 HP-IB Interface Card.

- VERF_QBC.EXE - this program requires an HP 82335 HP-IB Interface Card. The program was written in Microsoft® QuickBASIC using the HP-IB Command Library which comes with the HP 82335 HP-IB Interface Card.

- VERF_QBT.EXE - use this program if you wish to to verify the Command Module using the RS-232 port on the PC computer. The program was written in Microsoft® QuickBASIC.

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Programs for Windows™

- VERF_VBS.EXE - this program requires either an HP 82335, 82340, or 82341 HP-IB Interface Card. The program was written in Visual BASIC using the HP Standard Instrument Control Library (SICL), which comes with the HP 82340 or 82341 HP-IB Interface Card.

- VERF_VCS.EXE - this program requires either an HP 82335, 82340, or 82341 HP-IB Interface Card. The program was written in Visual C/C++using the HP Standard Instrument Control Library (SICL), which comes with the HP 82340 or 82341 HP-IB Interface Card.

Program for HP BASIC

- VERF_RMB - this program requires the HP-IB interface connection of an HP computer that has HP-IB capability (i.e., a series 200/300).

Load and run the appropriate program and follow the directions on the screen.

Note For information on how to control Command Module operation using the languages listed above, refer to Chapter 2.

Step 12B: Verifying Using Other Than The VERF_*XXX* Program

To verify mainframe operation using your own program language, send the following SCPI commands (Standard Commands for Programmable Instruments). (Refer to the "HP E1300/E1301 User's Manual" for more information on the mainframe SCPI commands.)

Checking for Start-Up Errors

To check for start-up errors, do the following:

1. Send the following SCPI command:

   VXI:CONFigure:DeviceLIST?

2. The returned message should look similar to the one below:

```
+0,-1,+4095,+1301,-1,+0,HYB,NONE,#H00000000,#H00000000,READY,"","","","SYSTEM IN
STALLED AT SECONDARY ADDR  0";+80,+0,+4095,+65440,-1,+0,REG,A16 ,#H00000000,#H00
000000,READY,"","","","ARB INSTALLED AT SECONDARY ADDR 10";+112,+0,+4095,+65296,
-1,+0,REG,A16 ,#H00000000,#H00000000,READY,"","","","SWITCH INSTALLED AT SECONDA
RY ADDR 14"
```

3. If the message indicates a start-up error, it may look similar to the one shown below (where the text in italics shows the actual error message):

```
+0,-1,+4095,+1301,-1,+0,HYB,NONE,#H00000000,#H00000000,READY,"","","","CNFG ERRO
R: 13";+112,+0,+4095,+65280,-1,+0,REG,A16 ,#H00000000,#H00000000,READY,"","","",
"CNFG ERROR: 13"
```


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For example, "CNFG ERROR: 13" shows that the Logical Address Switch may be set wrong. See Appendix Y for the different error messages and possible causes.

Note If "CNFG ERROR: 3" is noted, download the driver for the module that caused this error. After the driver is downloaded, perform the above step again. The procedure for downloading drivers is in the Operating Note that came with the driver.

Checking for System Errors

Send the following SCPI command:

```
SYSTem:ERRor?
```

If the mainframe is operational, the command returns this error message:

```
+0,"No error"
```

Checking and Setting the System Time

To check the system time, send:

```
SYSTem:TIME?
```

The returned message for the time is a comma separated list:

```
hh,mm,ss
```

where "hh" is the hour, "mm" are the minutes, and "ss" are the second. For example, if the returned message is "+23,+5,+38", it shows a time of 23:05:38 or 11:05:39 P.M. The time is in the 24 hour format.

To set the time, send:

```
SYSTem:TIME <hour>,<minute>,<second>
```

For example, to set the time for 10:15:00 AM, send:

```
SYST:TIME 10,15,00
```

Checking and Setting the System Date

To check the system date, send:

```
SYSTem:DATE?
```


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The returned message for the date is a comma separated list:

yyyy,mm,dd

where "yyyy" is the year, "mm" is the month, and "dd" is the day. For example, if the returned message is "+1994,+7,+24", it shows a date of 7/24/1994 or July 24,1994.

To set the system date, send:

```
SYSTem:DATE <year>,<month>,<day>
```

For example, to set the date for May 31, 1994, send:

```
SYST:DATE 1994,5,31
```

Where to go Next

Your B-Size system should now be installed and operational. Next, you should wire the terminal blocks and begin programming. Refer to the individual module manuals for wiring schematics and specific terminal block wiring information.

The next chapter (Chapter 2) shows how to program instruments using a variety of languages. Shipped with the command module are two "Verification and Example Programs" disks. These disks (one DOS and one LIF disk) contain example programs in various languages. Refer to the "README" files on the disks for information on the various programs on the disks.

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Chapter 2
Sending SCPI Commands

This chapter shows how to send Standard Commands for Programmable Instruments (SCPI) and IEEE 488.2 Common Commands to the HP E1306 Command Module from a computer over the Hewlett-Packard Interface Bus (HP-IB)*, or from a Terminal. Chapter contents are:

- Using Visual BASIC and HP SICL (HP Standard Instrument Control Library) 2-2
- Using C/C++and HP SICL (HP Standard Instrument Control Library) 2-5
- Using C and the HP-IB Command Library 2-10
- Using HP BASIC 2-13
- Using a Terminal 2-15

Verification and Example Programs

Shipped with the HP E1306 Command Module are two disks that contain verification and example programs for the command module. One disk (HP Part Number: E1300-10307) is in the LIF format and contains programs written for HP BASIC/IBASIC. The other disk (HP Part Number: E1300-10308) is in the DOS format and contains programs written in C/C++, Visual BASIC, QuickBASIC, and HP IBASIC.

Refer to the "README" files on the disks for information on the various programs on the disks.

Primary and Secondary HP-IB Addressing

The plug-in modules in the mainframe are considered individual instruments. This requires them to have a unique HP-IB Secondary address. This is because the Primary HP-IB address of each instrument is the same, which is the primary address of the mainframe itself. To determine the Secondary HP-IB address, divide the Logical Address of an instrument by 8.

For example, a typical HP-IB address is:

70903

where:

- "7" is the Select Code
- "09" is the Primary HP-IB address (default value)
- "03" is the Secondary HP-IB address (default value of the HP E1326 Multimeter); the "03" Secondary HP-IB address is derived from a Logical Address of 24 (i.e., 24 / 8 = 3)

* HP-IB is Hewlett-Packard's implementation of the IEEE Standard 488.1-1978

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Using Visual BASIC and HP SICL

The following shows how to use the Visual BASIC program language (version 3.0) with the HP Standard Instrument Control Library (SICL) and the HP 82335, HP 82340, or HP 82341 HP-IB Interface Card. Both the HP-IB Card and SICL are used in a PC type computer under Microsoft® Windows™ or Windows NT™.

The HP Standard Instrument Control Library provides the sub calls to send the SCPI commands that control instrument operation. To send a SCPI command, the appropriate sub call requires the HP-IB address of the instrument and the SCPI command. To receive data from the instrument, the appropriate sub call requires the HP-IB address and the returned data format. To send commands and to receive data is a multiple step process, as follows:

1. SICL first opens an I/O session between Visual BASIC and the instrument.
2. Send the commands and return the data to and from the instrument.
3. Close the the I/O session between Visual BASIC and the mainframe.
4. If using Microsoft® Windows™, cleanup SICL (not needed for Windows NT™).

Typical sub calls are as follows (refer to the "SICL Manual" for other commands):

What's Needed

Include the "SICL.BAS" program file to the Visual BASIC project. This file came with SICL. To add the file, press Ctrl-D and enter the path and file name, or select the Add File menu under the File menu (see Visual BASIC documentation for more information).

How to Run a Program

You can run the program in the Visual BASIC environment or compile it to make an executable file. Use the appropriate menu in the environment to make the executable file. Note that the file can only operate under Windows™.

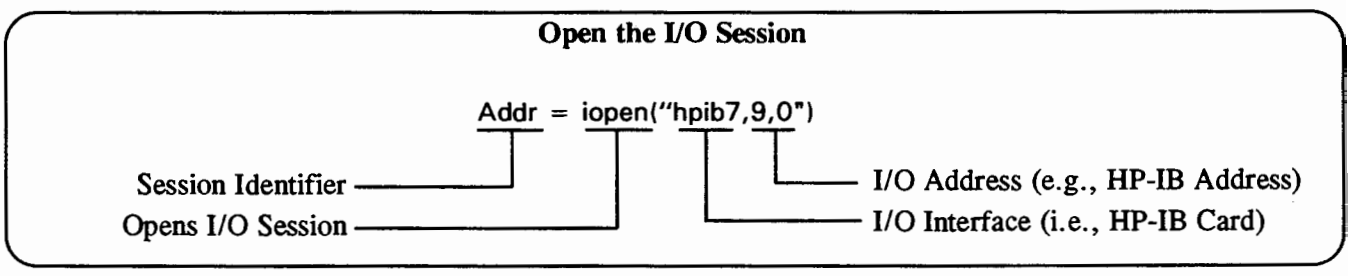
Sending SCPI Commands and Receiving Data

The following shows how to send SCPI commands and receive data. To do this, open the communication path between Visual BASIC and the instrument. The following shows how to open the path, and send and receive data.

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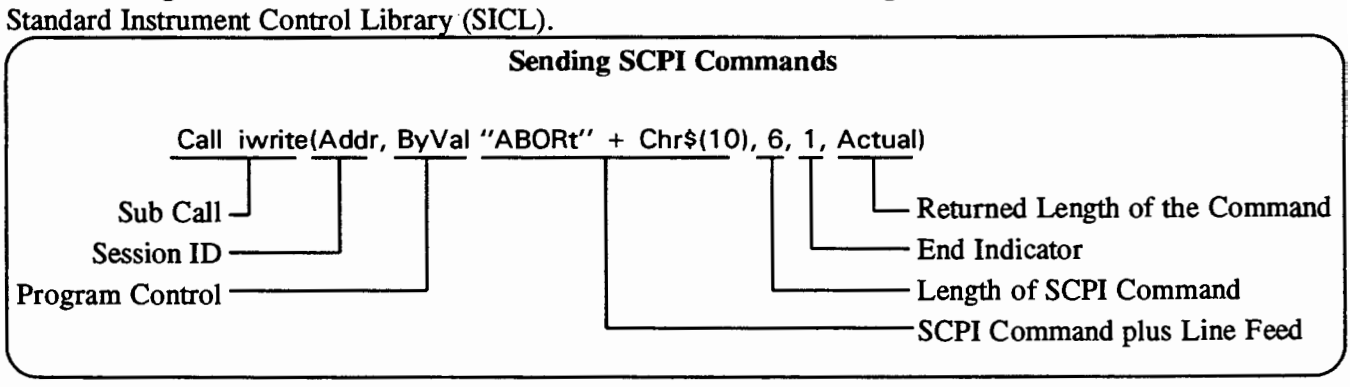
Open Communication Path

Use the iopen subroutine to open the communication path between the instrument and Visual BASIC. The command requires the complete HP-IB address.



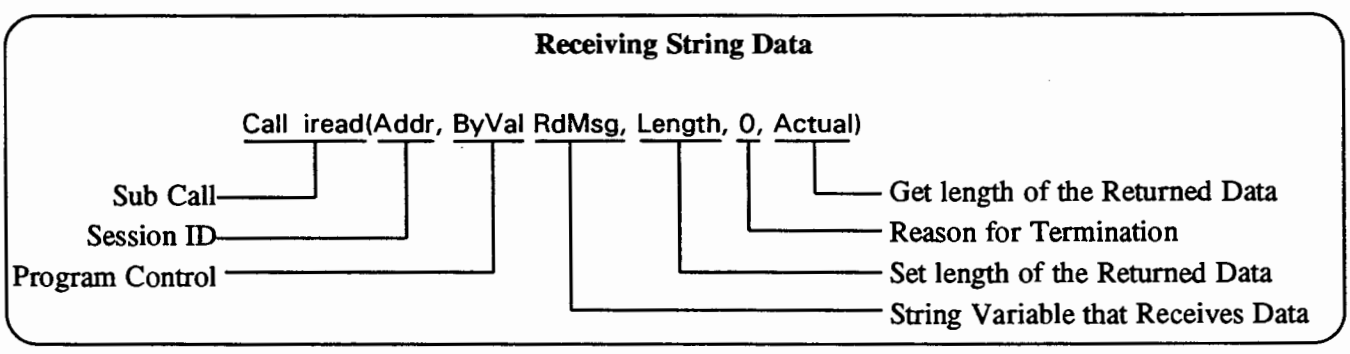
Sending SCPI Commands

The following shows how to send SCPI commands to an instrument using the iwrite subroutine from the HP Standard Instrument Control Library (SICL).



Receiving Data

The following shows how to use the iread subroutine from the HP Standard Instrument Library to receive string data from an instrument.



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Program Example

The following program example sends a SCPI command and returns the data into a string variable.

```
Sub Main ()

Dim Addr As Integer
Dim Cmd As String
Dim RdMsg As String * 256
Dim Length As Integer
Dim Actual As Long

   ' SCPI command
Cmd = "SYSTem:ERRor?" + Chr$(10)

   ' Open communication path using HP-IB address
Addr = iopen("hpib7,9,0")

   ' Send SCPI command
Call iwrite(Addr, ByVal Cmd, Len(Cmd), 1, Actual)

   ' Set space for returned data
Length = 256

   ' Get readings
Call iread(Addr, ByVal RdMsg, Length, 0, Actual)

   ' Show readings
MsgBox RdMsg, 0

   ' Close communication with instrument
Call iclose(Addr)

   ' Clean up sicl (for Windows only)
Call siclcleanup

End

End Sub
```


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Using C/C++ and HP SICL

The following shows how to use the Visual C/C++program language with the HP Standard Instrument Control Library (SICL) and the HP 82335, HP 82340, or HP 82341 HP-IB Interface Card. Both the HP-IB Card and SICL are used in a PC type computer under Microsoft® Windows™ or Windows NT™.

The HP Standard Instrument Control Library provides the functions to send the SCPI commands that control instrument operation. To send a SCPI command, the appropriate function requires the HP-IB address of the instrument and the SCPI command. To receive data from the mainframe, the appropriate function requires the HP-IB address and the returned data format. To send commands and receive data is a multiple step process, as follows:

1. SICL first opens an I/O session between C/C++ and the mainframe.
2. Send the commands and return the data to and from the mainframe.
3. Close the the I/O session between C/C++ and the mainframe.
4. If using Microsoft® Windows™, cleanup SICL (not needed for Windows NT™).

Typical functions are as follows (refer to the "SICL Manual" for other commands):

What's Needed

You need the the following libraries and header files. These are supplied with SICL.

- msapp16.lib - for Microsoft® Visual C +and C++
- bcapp16.lib - Borland C and C++
- sicl16.lib
- sicl.h

How to Run a Program

To run a program, first compile and link the program to make an executable file using the Large memory model. You can compile from the command line or the Windows™ interface. The two methods are:

From the Command Line

Make sure the program to be compiled and the appropriate libraries are in a project file. Do this in the C/C++ environment. Then do the following:

- For Borland compilers, type:

  MAKE <project_name>.MAK and press Enter

- For Microsoft compilers used in Windows, type:

  NMAKE <project_name>.MAK and press Enter

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From the Windows Interface

Select the C/C++ Windows environment and make sure the program to be compiled and the appropriate libraries are in a project file. Then do the following:

- For Borland compilers, select:

  Project | Open Project to open the project, then
  Compile | Build All to compile the program

- For Microsoft compilers used in Windows, type:

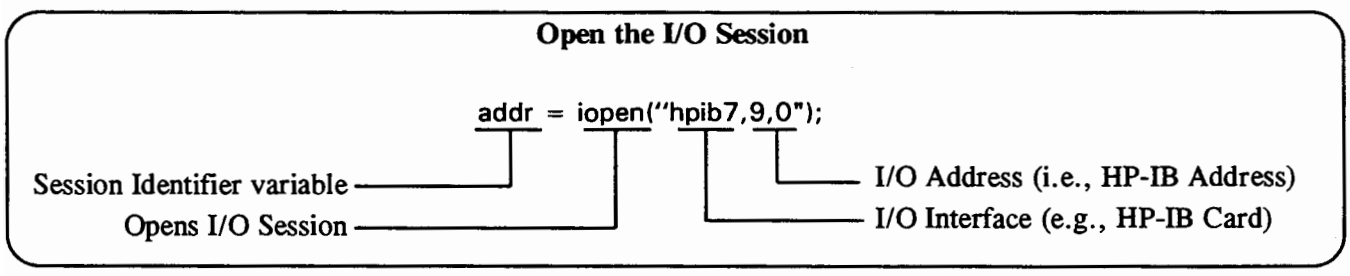
  Project | Open to open the project, then
  Project | Re-build All to compile the program

Sending SCPI Commands and Receiving Data

The following shows how to send SCPI commands and receive data using several different functions. To do this, open the communication path between Visual C/C++ and the instrument. The following shows how to open the path, and send and receive data.

Open Communication Path

Use the iopen function to open the communication path between the instrument and Visual C/C++. The command requires the complete HP-IB address.



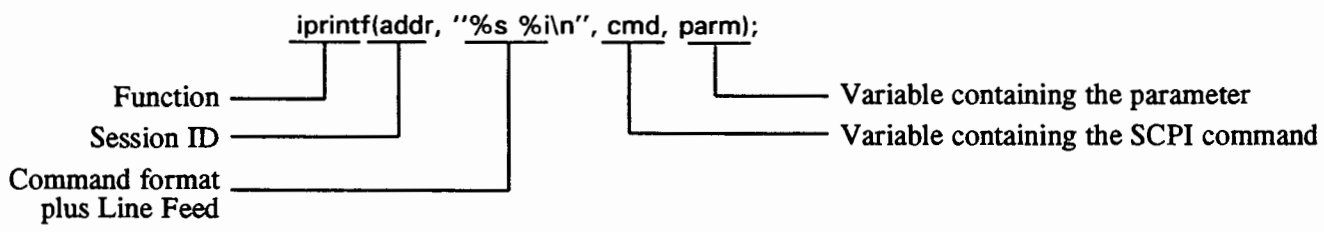
Sending SCPI Commands

The following shows two ways to send SCPI commands. One way uses the iprintf function from the HP Standard Instrument Library to send the commands as formatted data to the instrument. The other way uses the iwrite function to send the commands in a block of data.

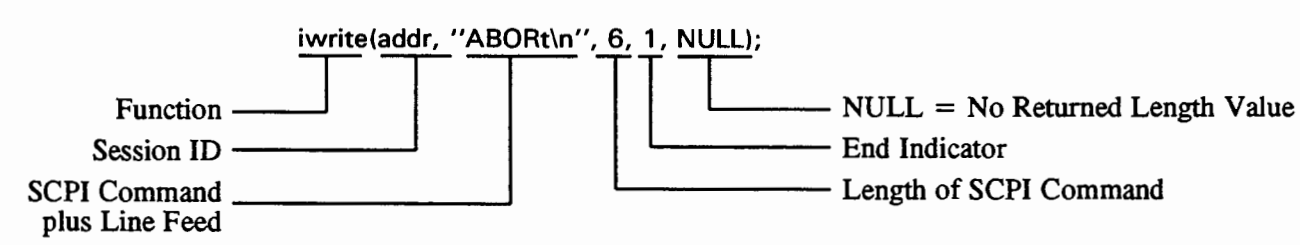
Use the iwrite function to send SCPI commands that will not change and use the iprintf function to send SCPI commands where the parameters may change. The format for the iprintf command are the same format used by C/C++ (e.g., %s, %i, %f, etc.).

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Sending SCPI Commands as Formatted Data



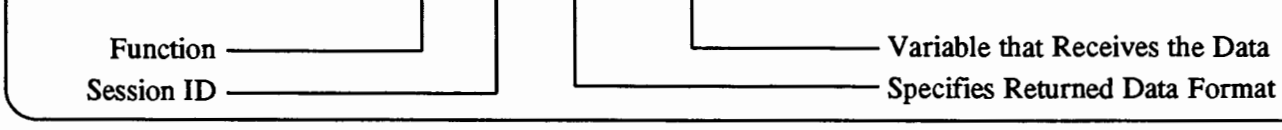
Sending SCPI Commands as a Block of Data



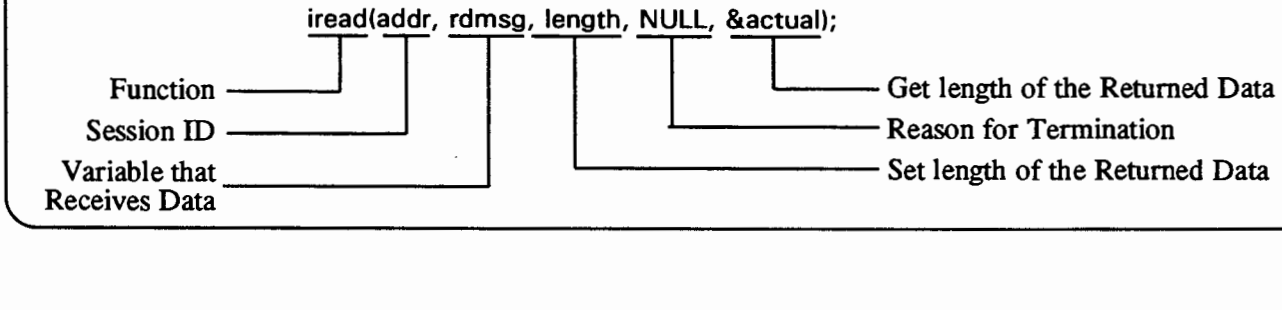
Receiving Data

The following shows two ways to receive data. One way shows how to use the iscanf function from the HP Standard Instrument Library to receive formatted data from an instrument. The other way uses the iread function to receive unformatted data.

Receiving Formatted Data



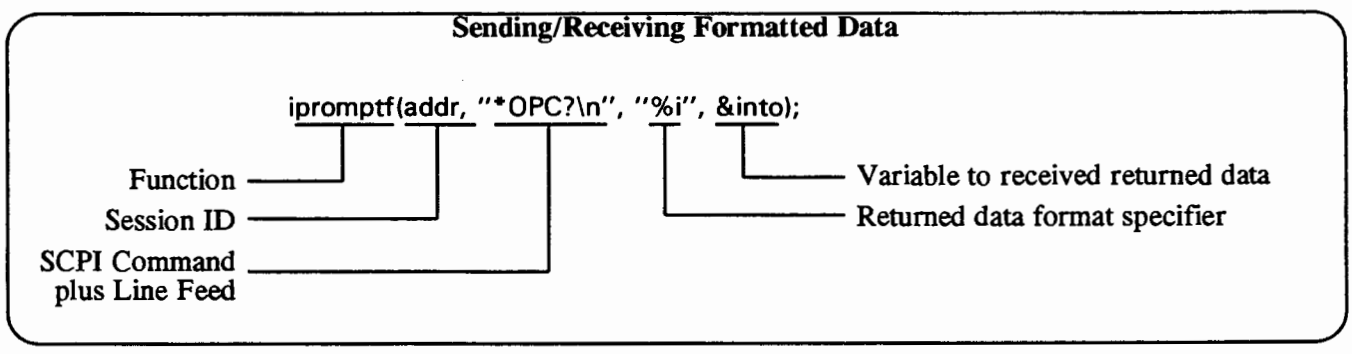
Receiving Unformatted Data



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Using Single Function to Send and Receive Data

The ipromptf function sends formatted SCPI commands and immediately reads the returned data as formatted data. This function is a combination of the iprintf and iscanf functions.



Program Example to Send and Read Unformatted Data

The following program example uses the "iread" function to read unformatted raw data.

```
#include <stdio.h>
#include <string.h>
#include <sicl.h> /* Included with SICL */

#define DEV_ADDR "hpib7,9,0"    /* Assign the instrument HP-IB address */

/*********************************************************************/
void main(void)
{
    INST    addr;
    unsigned long actual;
    int     length = 256;
    char    into[256],
            *cmd = "SYSTem:ERRor?\n";  /* SCPI command */

    #if defined(__BORLANDC__) && !defined(__WIN_32)
      _InitEasyWin();        /* Required for Borland EasyWin program */
    #endif

      /* Enable communication path to the instrument */
    addr=iopen(DEV_ADDR);

      /* Send SCPI command */
    iwrite(addr, cmd, strlen(cmd), 1, NULL);
```

Continued on Next Page

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```
    /* Read returned data */
  iread(addr, into, length, NULL, &actual);

    /* NULL terminates result string and print the results */
  if (actual)
  {
    into[actual - 1] = (char) 0;
    printf("\n%s", into);
  }

    /* Close communication */
  iclose(addr);

    /* Release SICL resource allocation; not needed for Windows NT */
  _siclcleanup();
}
```

Example to Read Formatted Data

To read formatted data, replace the "iread" function in the above program with the "iscanf" function.

```
    /* Read retumed data */
  iscanf(addr, "%t", into);

    /*Print the results */
  printf("\n%s", into);
```

Example to Send and Read Formatted Data

To send and read formatted data, replace the "iscanf" and "iprintf" functions with the "ipromptf" function.

```
    /* Send SCPI command and read returned data */
  ipromptf(addr, "SYSTem:ERRor?\n", "%t", into);
```


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Using C and the HP-IB Command Library

The following shows how to use the C program language with the HP-IB Command Library and the HP 82335 HP-IB Interface Card (the command library is supplied with the HP-IB Card). Both the HP-IB Card and Command Library are used in a PC type computer.

The HP-IB Command Library provides the functions to send the SCPI commands that control instrument operation. To send a SCPI command, the C function requires the HP-IB address of the instrument (e.g., 70900) and the SCPI command. To receive data from the instrument, the C function requires the HP-IB address and the returned data format. Typical functions to send commands and to receive data are as follows (refer to the "HP-IB Command Library Manual" for other commands).

Supported C Programs

The supported C programs are:

- Microsoft® C +and C++
- Borland C and C++

What's Needed

You need the the following libraries and header files. These are supplied with the command library.

- clhpib.lib - for Microsoft® C +and C+
- tchhpib.lib - for Borland C and C++
- cfunc.h - for the Small memory model only

Executing a Program

To execute a program, first compile and link the program to make an executable file. To compile the program from the command line:

- Link the appropriate HP-IB C library (from the HP-IB Command Library files). Use one of the following libraries:
  - Microsoft® C +and C++, and QuickC©: clhpib.lib
  - Borland C and C++: tchhpib.lib

- If using the Small memory model, include "cfunc.h" header file (from the HP-IB Command Library files). This file is not needed when using the Large/Huge memory models.

- Be sure the necessary paths have been added to the AUTOEXEC.BAT file for the compilers to find the correct library and header file (see your C Language documentation to set the proper paths).

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Compiling a Program

To compile a program from the DOS command line using the Large memory model, execute the following:

- Microsoft® C/ and C++:

  cl /AL <*path*\program name.C> *path*\clhpib.lib

- Borland C and C++:

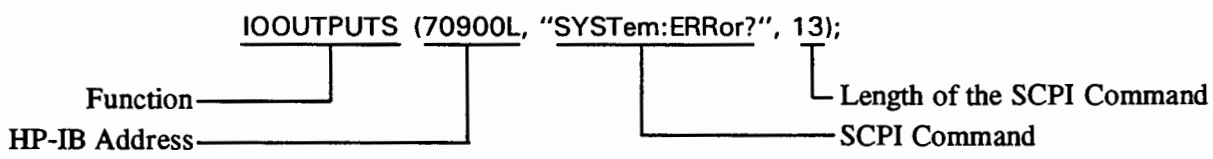
  tcc -ml <*path*\program name.C> *path*\tchhpib.lib

When using the Small memory model, change the "AL" or "-ml" parameters to "AS" or "-ms".

Sending SCPI Commands

The following shows how to use the IOUTPUTS function from the HP-IB Command Library to send SCPI commands to an instrument. The function needs the complete HP-IB address of the instrument.

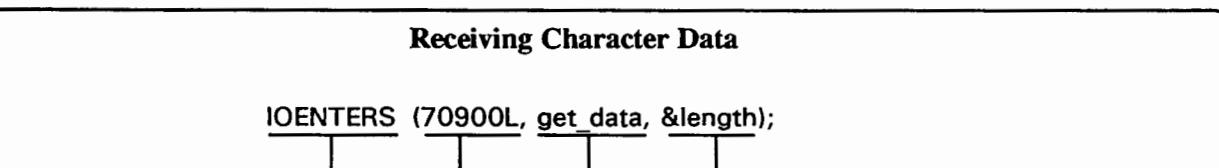
Sending SCPI Commands



Receiving Data

The following shows how to use the IOENTERS function from the HP-IB Command Library to receive character data from an instrument. The function needs the complete HP-IB address of the instrument.

Receiving Character Data



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Program Example

The following program example sends a SCPI command and returns the data into a character string.

```
#include <stdio.h>
#include <string.h>
#include <cfunc.h>     /* This file is from the HP-IB Command Library Disk */

#define ADDR 70900L  /* Defines the HP-IB address */

/*****************************************************************/
void main(void)
{
      char     *cmd = "SYSTem:ERRor?",     /* SCPI command */
               rd_msg[257];
      int      length = 256;

         /* Send SCPI command */
      IOOUTPUTS(ADDR, cmd, strlen(cmd));

         /* Read returned data */
      IOENTERS(ADDR, rd_msg, &length);

         /* Print returned data */
      printf("\n%s",rd_msg);
}
```


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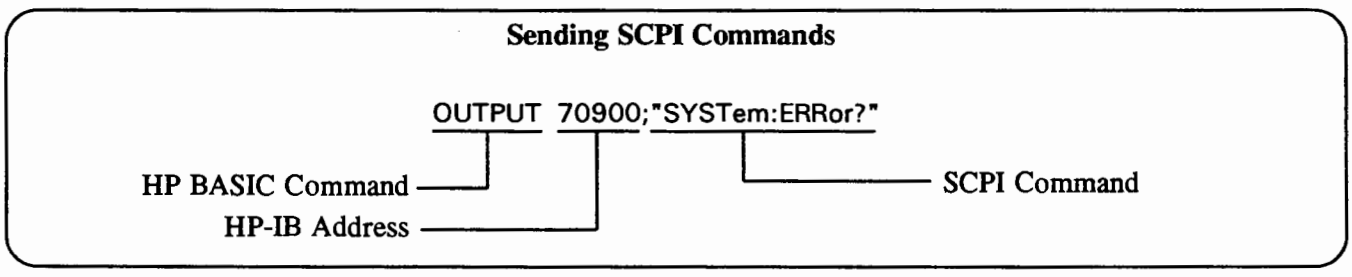
Using HP BASIC

The following shows how to use the HP BASIC program language (version 5.0 and above). HP BASIC language is in a variety of HP computers, including many Series 200/300 computers. These computers normally have the means for HP-IB connections.

HP BASIC has the means to directly send commands to the instruments and to directly receive data from the instruments over HP-IB. To send a SCPI command, the program requires the HP-IB address of the instrument and the SCPI command. To receive data from the instrument, the program requires the HP-IB address. Typical commands are as follows (refer to the HP BASIC documentation for other commands).

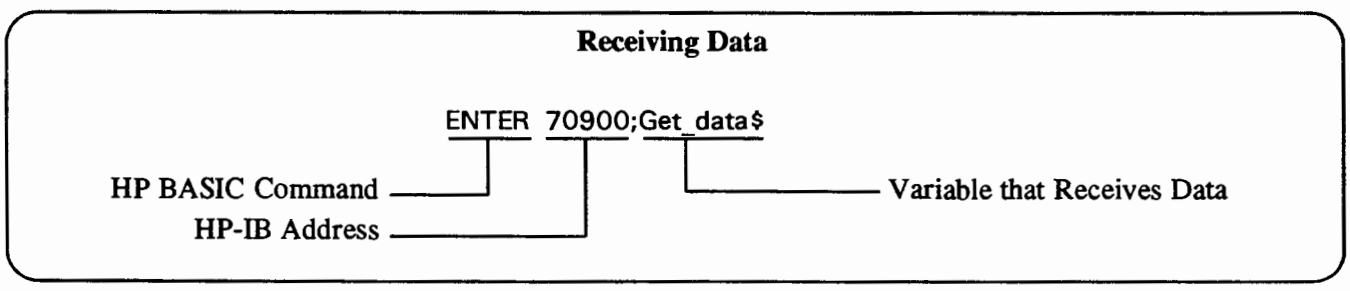
Sending SCPI Commands

The following shows how to send SCPI commands to an instrument using the HP BASIC OUTPUT command. The command needs the complete HP-IB address of the instrument.



Receiving Data

The following shows how to use the hp BASIC ENTER command to receive data from an instrument. The command needs the complete HP-IB address of the instrument.



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Program Example

A typical program example is as follows. This example sends a SCPI command and returns the data into a string variable.

```
10 DIM A$[256]
20 !
30 ! Send SCPI command
40 OUTPUT 70900.;"SYSTem:ERRor?"
50 !
60 ! Read data
70 ENTER 70900.;A$
80 !
90 ! Print returned data
100 PRINT A$
110 END
```


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Using a Terminal

The following shows how to use a supported terminal to send SCPI commands to an instrument and display returned data. The supported terminals are:

- HP 700/92
- HP 700/94
- HP 700/22
- HP 700/43
- DEC® VT100®
- DEC® VT220®
- WYSE® WY-30™
- HP AdvanceLink terminal emulation software (configured as an HP 2392A Terminal)

Connecting the Terminal

The terminal must be connected to the RS-232 connector on the computer. The Baud Rate must be 9600.

Sending SCPI Commands

To send SCPI commands to an instrument, make sure the instrument is selected. You can select the instrument either in the main menu or in an instrument menu, as follows:

Select Instrument from Main Menu

The Main Menu is the one that is shown after the mainframe is turned on and it has gone through its turn-on cycle. The prompt "Select an instrument" is displayed when the mainframe is ready to select an instrument. Do the following:

1. **Supported Terminal:** The installed instruments are shown on the terminal's functions keys. To select an instrument, press the appropriate function key. For example, if you wish to select the system (i.e., mainframe), press the function key labeled "SYSTEM".
2. **Non-Supported Terminal:** Do one of the following:

   a. Type:

      SI <instrument name> press Return

   where, <instrument name> is the name of the instrument to be selected. For example, the function key labeled "VOLTMTR" for the HP E1326 Multimeter.

   or type:

      SA <logical Iddress>

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where <logical address> is the Logical Address of the instrument to be selected. For example, "SA 24" selects the HP E1326 Multimeter.

Select Instrument from an Instrument Menu

An Instrument Menu is normally indicated by the instrument title shown on the display. For example, if the system is selected, the title is typically displayed as "SYSTEM_0:". Do the following:

1. **Supported Terminal:** Do the following:
   a. Press the function key labeled "UTILS", if displayed. Continue with the next step if the label is displayed or not.
   b. Press the function key labeled "SEL_INST". This should bring you to the Main Menu (i.e., the "Select an instrument." prompt shown). Use the procedure under the "Select Instrument from Main Menu" heading to select the instrument.
2. **Non-Supported Terminal:** Press Ctrl-D to select the Main Menu (i.e., the "Select an instrument." prompt shown). Use the procedure under the "Select Instrument from Main Menu" heading to select the instrument.

Sending the Commands

Once the instrument menu is shown, type in the SCPI command and press 'Return'. For example, to display an error message, type:

```
SYST:ERR?
```

and the returned error message from the selected instrument will be displayed.

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Appendix A
In Case Of Difficulty

This appendix gives possible failures and troubleshooting information for the mainframe. Included are start-up and system errors, and their descriptions.

No Communication Between Command Module And Computer

When the command module is unable to communicate with the computer, do the following:

1. Check for poor interface connections (HP-IB or Serial I/O) between the computer and mainframe. If connections are good, continue with step 2.
2. Turn the mainframe off.
3. Remove all plug-in modules, except the command module, from the mainframe.
4. Turn the mainframe on; wait until it goes through its turn on cycle (about 8 seconds).
5. Try to communicate with the command module again (send the "VXI:CONFigure:DeviceLIST?" command or use the "VERF_*XXX*" program from the B-Size Verification Disk).
6. If the command module is now operative, do the following:
   a. Turn the mainframe off.
   b. Plug in one plug-in module.
   c. Turn the mainframe on.
   d. Check for correct operation again (see step 4).
   e. If the command module is now inoperative, the last module installed is defective. If the command module module still operates, repeat steps 5-a to 5-d to check any other modules one at a time until you find the defective one.
7. If the mainframe is still inoperative, make sure the computer operates correctly. If it appear to operate correctly, the mainframe is inoperative.

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Start-Up Errors and Messages

The Start-up errors and descriptions are listed in Table A-1.

Table A-1. Start-Up Errors

Code	Message	Cause
1	Failed Device	VXI device failed its self test.
2	Unable to combine device	Device type can not combine into an instrument such as a scanning voltmeter or a switchbox.
3	Config warning. Device driver not found	Identification of device does not match list of drivers available.
5	Config error 5. A24 memory overflow	More A24 memory installed in the command module that can be configured into available A24 memory space.
8	Config error 8. Inaccessible A24 memory	An A24 memory device overlaps a memory space reserved in the mainframe's operating system.
10	Config error 10. Insufficient system memory	Too many instruments installed for the amount of RAM available in the command module. Cannot configure the instruments. Only the command module is started.
11	Config error 11. Invalid instrument address	A device that is not part of a combined instrument has a logical address that is not a multiple of 8.
13	Config error 13. Logical address or or IACK switch set wrong	Duplicate logical addresses set or interrupt bypass switches set improperly. Only the command module is started.
29	Config warning. Sysfail detected	A device asserted SYSFAIL on the backplane during startup.
30	Config error 30. Pseudo instrument logical address unavailable	A physical device has the same logical address as IBASIC (i.e., 30).
31	Config error 31. File system start up failed	Insufficient system resources to allow the IBASIC file system to start.
45	Config warning. Non-volatile RAM contents lost	NVRAM was corrupted or a cold boot was executed.
48	Config warning. Driver RAM contents lost.	Driver RAM was corrupted or a cold boot was executed.

Error: 1: Failed Device

This indicates that a plug-in module in the mainframe is inoperative. To determine which module is defective, do the following:

1. Remove AC power from the mainframe.
2. Unplug a module (except the command module).
3. Re-apply AC power to the mainframe and check for Start-Up errors again.
4. If the error has not returned, the last module unplugged is the cause. Otherwise, repeat steps 1 to 3 to check the other modules.

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Error: 3: Config warning. Device driver not found

The command module generates this error when it detects a module that has no driver present. Many instruments, like the HP E1326 Multimeter and HP E1345/E1346/E1347, etc. switches, have the built-in drivers in ROM. For other modules, like the HP E1340 Arbitrary Function Generator, its driver must be downloaded.

When Error: 3 is generated, check and be sure all drivers are installed. Refer to the Downloadable Driver Operating Note that came with module to download the drivers.

Error 10: Config error 10. Insufficient system memory

The system has a set amount of RAM memory available for use. If attempting to download instrument drivers that require more RAM memory than available, the system generates this error message. Either install more RAM or remove a downloadable driver to get more memory.

Error 11: Config error 11. Invalid instrument address

The command module generates this error if a Logical Address of a module is other than a multiple of 8. The only exception is the Scanning Voltmeter or Switchbox configuration. However, the first module in these configurations must be set at a multiple of 8.

Error 13: Config error 13. Logical address or IACK switch set wrong

Multiple modules with the same Logical Address causes this error. Be sure each module has its own unique Logical Address.

System Errors and Messages

All system errors generated by the command module are stored into an error queue until full. When full, all subsequent errors are not stored. Before the error queue is full, the last error message stored is called:

```
-350,"Too many errors"
```

Reading the Error Queue

The SCPI command "SYSTem:ERRor?" reads the error queue and returns the error message. The command reads the oldest message to the newest/ Whenever a message is read, it is removed from the queue. When all messages are removed, the command returns:

```
+0,"No error"
```


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Error Types

The returned error message consists of a number and a message. A positive number shows instrument specific errors. Negative numbers determined different types of errors as summarized in Table A-2. The different negative numbered types are explained following the table.

Table A-2. Negative Error Numbers

Error Number	Error Type
-199 to -100	Command Errors
-299 to -200	Execution Errors
-399 to -300	Device-Specific Errors
-499 to -400	Query Errors

Command Errors

The command module cannot execute or understand a command. Possible causes are:

- A syntax error. For example, wrong data type for a particular command was received.
- A command was not recognized. For example, the SCPI or Common Command is incorrect.

Execution Errors

The command module is unable to perform the action or operation requested by the command. Possible causes are:

- A parameter within the command is outside the limits or inconsistent with the capabilities of the command module.
- A valid command cannot be executed due to a failure in the command module.

Device-Specific Errors

This shows that an operation cannot complete due to to an abnormal hardware or firmware condition, like a self-test failure.

Query Errors

This shows that a problem has occurred in the output queue. Possible causes are:

- An attempt was made to read an empty output queue (i.e., no data present in the queue).
- Data in the output queue has been lost for some unknown reason.

System Error Message Listing

For a listing of all system errors, refer to Tables A-3 and A-4.

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Table A-3. System Errors

Code	Message	Cause
-101	Invalid character	Unrecognized character in specified parameter.
-102	Syntax error	Command is missing a space or comma between parameters.
-103	Invalid separator	Command parameter is separated by some character other than a comma.
-104	Data type error	The wrong data type (i.e. number, character, string expression) was used when specifying a parameter.
-108	Parameter not allowed	Parameter specified in a command which does not require one (e.g., SYSTem:ERRor? 10).
-109	Missing parameter	No parameter specified in the command in which a parameter is required.
-113	Undefined header	Command header was incorrectly specified (e.g., *IDN1?).
-123	Numeric overflow	A parameter specifies a value greater than the command allows.
-128	Numeric data not allowed	A number was specified for a parameter when a letter is required.
-131	Invalid suffix	Parameter suffix incorrectly specified (e.g. .SSECOND rather than .SS or .SSEC).
-138	Suffix not allowed	Parameter suffix is specified when one is not allowed.
-141	Invalid character data	The discrete parameter specified is not allowed (e.g. TRIG:SOUR INT - INT is not a choice.).
-178	Expression data not allowed	A parameter is enclosed in parentheses that should not be.
-211	Trigger Ignored	Trigger occurred while the Pacer is in the idle state, or a trigger occurred from a source other than the specified source.
-222	Data out of range	The parameter value specified is too large or too small.
-224	Illegal parameter value	The numeric value specified is not allowed.
-240	Hardware error	Hardware error detected during power-on cycle. Return command module to Hewlett-Packard for repair.
-310	System error	If caused by *DMC, then macro memory is full.
-350	Too many errors	The error queue is full as more than 30 errors have occurred.
-410	Query interrupted	Data is not read from the output buffer before another command is executed.
-420	Query unterminated	Controller tried to read data without first sending a complete query message.
-430	Query deadlocked	Command execution cannot continue since the command module's command input and data output buffers are full. Clearing the instrument restores control.
+1500	External trigger source	"Event In" signal already allocated to another already allocated instrument such as a Switchbox.
+2002	Invalid logical address	A value less than 0 or greater than 255 was specified for for a logical address.

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Table A-4. System Errors (cont.)

Code	Message	Cause
+2003	Invalid word address	A odd address was specified for a 16 hit read or write. Always use even addresses for 16 bit (word) accesses.
+2005	No module at logical address	A non-existent logical address was specified with the VXI:READ? or VXI:WRITE command.
+2101	Failed Device	VXI device failed its self test.
+2102	Unable to combine device	Device type can not be combined into an instrument such as a scanning multimeter or a switchbox.
+2103	Config warning, Device driver not found	ID of device does not match list of drivers available. Warning only.
+2105	Config error 5, A24 memory overflow	More A24 memory installed in the command module than can be configured into the available A24 memory space.
+2108	Config error 8, Inaccessible A24 memory	A24 memory device overlaps memory space reserved by the command module's operating system.
+2110	Config error 10, Insufficient system memory	Too many instruments installed for the amount of RAM installed in the command module. Cannot configure instruments. Only the system is started.
+2111	Config error 11, Invalid instrument address	A device's logical address is not a multiple of 8 and the device is not part of a combined instrument.
+2113	Config error 13, Logical address or IACK switch set wrong	Duplicate logical addresses set or interrupt bypass switches set improperly. Only the system is started.
+2129	Config warning, Sysfail detected	A device was asserting SYSFAIL on the backplane during startup.
+2130	Config error 30, Pseudo instrument logical address unavailable	A physical device has the same logical address as IBASIC (240).
+2131	Config error 31, File system start up failed	Insufficient system resources to allow IBASIC file system to start.
+2145	Config warning, Non-volatile RAM contents lost	NVRAM was corrupted or a cold boot was executed.
+2148	Config warning, Driver RAM contents lost	Driver RAM was corrupted or a cold boot was executed.
+2202	Unexpected interrupt from non-message based module	A register-based module interrupted when an interrupt service routine had not been set up.
+2809	Interrupt line has not been set up	A DIAG:INT:ACT or DIAG:INT:RESP command was executed before setting the interrupt with DIAG:INT:SET.

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Appendix B
Debugging VXI SCPI Programs

Introduction

This appendix shows how to debug programs for the command module and other installed modules using the Standard Commands for Programmable Instruments (SCPI). SCPI provides a common language for the mainframe and modules to simplify programming and debugging. For specific commands, refer to the command module and other module's User's manuals.

Steps To Debug Programs

Perform the following steps if your program does not produce the expected results. Steps 1 to 4 help find most programming errors and steps 5 to 8 find the more difficult errors that the previous steps may not find.

1. Verify Instrument Communication
2. Reset Each instrument at the Start of the Program
3. Query the Instruments for Errors
4. Query All Command Parameter Settings that are Set
5. Check the Program is Trying to Enter the Same Amount of Data the instrument is Trying to Output
6. Check the Instrument's Arm/Trigger Subsystem
7. Check that Coupled Commands are Sent as a Group
8. Check for Command Synchronization

Note Most of the examples in the following steps use HP BASIC as the program language.

Step 1: Verify Instrument Communication

Use this step to determine if the program can communicate with the instruments in the mainframe.

Logical and HP-IB Addressing

The HP VXI system contains either a command module or a mainframe with a built-in command module. The default Logical Address of the command module is normally 0 which makes the HP-IB Secondary address 0. The default Primary HP-IB address is 09. If the program can communicate with the mainframe/command module using these addresses, the program can determine other instruments in the mainframe. The first code in the HP-IB address is the Select Code. Most computers will most likely use a Select Code of 7.

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Typical HP-IB addresses for different program languages and libraries are:

- 70900 - HP BASIC
- 70900 - sent as a Long Integer in QuickBASIC using the HP-IB Command Library
- 70900L - sent as Long Integer in C using the HP-IB Command Library
- hpib7,9,0 - sent as string in Visual BASIC using the HP Standard Instrument Control Library (SICL)
- hpib7,9,0 - sent as character string in Visual C/C++ using the HP Standard Instrument Control Library (SICL)

Determining System Information

The VXI-5 document specifies a standard set of commands to access VXI system information. These commands follow the convention used in SCPI and IEEE 488.2. Use the following commands to determine system information.

Determine Logical Addresses

Use the VXI:CONFigure:LADDress? command to determine all Logical Addresses in the mainframe. This allows you to determine the Secondary HP-IB address of each instrument and also make sure the Logical Address switches are set correctly. A common mistake is to interpret the Most Significant Bit (MSB) for the Least Significant Bit (LSB), or a 1 for a 0. Execute from BASIC:

```
DIM A$[128]                          ! Dim variable for returned data
OUTPUT 70900.;"VXI:CONF:LADD?"       ! Send SCPI command
ENTER 70900.;A$                      ! Enter returned data
PRINT A$                             ! Print returned data
```

The command typically returns the data which returns data that may typically look like this:

```
+0,+24,+112,+113
```

Note that an instrument must have a Logical Address that is a multiple of 8.

Determine Additional Information

Execute the following commands to determine additional information about an instrument. Execute from HP BASIC:

```
DIM A$[128]                          ! Dim variable for returned data
OUTPUT 70900;"VXI:CONF:SEL 24"       ! Select instrument at Logical Address 24
OUTPUT 70900;"VXI:CONF:INF?"         ! Get instrument information
ENTER 70900.;A$                      ! Enter returned data
PRINT A$                             ! Print returned data
```

Determining Instrument Communication

Use the *IDN? command to determine if the computer can communicate with the instrument. Send the command using the Secondary HP-IB address (i.e., Logical Address / 8) of the instrument. The following HP BASIC sends to command to an instrument at Logical Address 24 (Secondary HP-IB address of 03)::

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```
DIM A$[128]                    ! Dim variable for returned data
OUTPUT 70903;"*IDN?"           ! Send *IDN? command to instrument at Logical Address 24
ENTER 70903;A$                 ! Enter returned data
PRINT A$                       ! Print returned data
```

Program Message Terminator

All command sequences must end with a proper program message terminator. This could be a Line Feed (LF), a Line Feed with an EOI statement, or an EOI statement. Programs like HP BASIC, or the functions/subroutines of the HP-IB Command Library automatically provides a Line Feed at the end of an OUTPUT or IOOUTPUTS statement, respectively. For the functions/subroutines of the HP Standard Instrument Library (SICL), the program must supply the terminator.

Step 2: Reset Each instrument at the Start of the Program

After a power-on occurs (i.e., mainframe is turned on), each instrument in the mainframe is fully reset. Since after using an instrument, it may be in a different state than when first turned on. The only way to reset to its power-on condition, is to go through the following three stages of reset.

1. Issue an IEEE 488 Interface Clear command. This command opens any handshaking between the computer and all instruments on the bus selected by the HP-IB Select Code. The following lists the Interface Clear command for several languages:

   a. ABORT <select code> - HP BASIC
   b. IOABORT (<select code>) - QuickBASIC using the HP-IB Command Library
   c. IOABORT (select code) - C/C++using the HP-IB Command Library

2. Issue an IEEE 488 (or HP-IB) Selected Device Clear. This command terminates instrument activity and clears input/output buffers to prepare to receive ASCII commands The following lists the Interface Clear command for several languages:

   a. CLEAR <HP-IB address> - HP BASIC
   b. IOCLEAR(<device_address>) - C using the HP-IB Command Library
   c. iclear(<device_session_id>) - using the Standard Instrument Control Library (SICL)

3. Reset all features of each instrument and wait for its completion, shown as follows using an HP BASIC program:

   ```
   OUTPUT 70900;"*RST;*CLS;*ESE 0;*SRE 0;*OPC?"
   ENTER 70900;A
   ```

   The *CLS;*ESE 0;*SRE 0 resets the instrument status system that is defined by IEEE 488.2. The *OPC? command outputs a "1" after all previous commands are completed (see "Step 8: Check for Command Synchronization" for more information on the command).

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Step 3: Query the Instruments for Errors

All instruments that follow the SCPI definition have an Error Queue. Each error that occurs is stored into the queue. To read the queue, send the command:

```
SYSTem:ERRor?
```

the returned message consists of an error number and message. If no errors are in the queue, the command returns:

```
+0,"No error"
```

This command is a very useful command since it can determine if the correct SCPI command has been sent to an instrument and that the parameters sent with the command are correct. If, for example, an incorrect command was sent, an error message is stored in the error queue after the command is parsed. Since the incorrect command may not otherwise indicate an error condition, the only way to find out is to query the Error Queue. The following shows how to continuously read the Error Queue until no more errors are stored using HP BASIC:

```
REPEAT                          ! Start a continuous loop
  OUTPUT 70900;"SYST:ERR?"      ! Send query command
  ENTER 70900;A,A$              ! Enter returned data
  PRINT A;A$                    ! Print error number and message
UNTIL A=0                       ! Loop until no errors are returned
```

Step 4: Query All Command Parameter Settings that are Set

If there is an error in the Error Queue, you must find out which command caused the error. A command with parameters that are incorrect will not be executed, but will generate an error in the queue. Reading the queue may not tell you which parameter caused the error. To do this, query the command itself to determine which parameters have been set. When the queried setting is different than what it is intended to be, the error is then located. For example, the following shows a typical command and the query form of the command:

```
:SOUR:CLOSE (@100)      command to close a channel
:SOUR:CLOSE? (@100)     command to query a channel
```

SCPI commands have levels similar to a computer path name. A colon separates the different levels. The spelling in each level must be correct or the instrument generates an error. Note that each command also has an abbreviated version. However, the command can only be sent as the full command or the abbreviated version. The abbreviated version are normally shown as upper case letters in the instrument manuals. All commands can be sent either using upper or lower case letters or a combination thereof.

Some common command errors are as follows:

- command spelling
- missing the space between the command and parameter

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- parameter out of range
- setting conflict caused by coupled commands not sent as a group (see "Step 8: Check that Coupled Commands are Sent as a Group"

Step 5: Check the Program is Trying to Enter the Same Amount

An error is caused if the program is set to receive different amount of data than the instrument is attempting to output. Do the following:

- Check the parameters in Step 4 and make sure the number of data items that you programmed to receive
- Determine if the arrays in the program are dimensioned correctly (e.g., arrays start with 0 or 1)
- Be sure you know that multiple results are returned as a comma separated list

The following HP BASIC is a typical example that receives multiple readings:

```
DIM A(1:10)                              ! Dimension array for 10 readings
OUTPUT 70903;"SAMP:COUNT 10;:READ?"  ! Take 10 readings using the HP 1326 Multimeter
ENTER 70903;A(*)                         ! Enter all 10 readings
```

Step 6: Check the Instrument's Arm/Trigger Subsystem

All SCPI instruments follow an Arm/Trigger model that is described in the SCPI document. This model has both required and optional levels, as follows:

Model Level	Required/Optional	Comment
IDLE	Required	
INITiated	Required	
LAYER <x>	Optional	This is the slowest occurring enabling event
LAYER <2>	Optional	
LAYer1	Optional	
TRIGger	Optional	This is the fastest occurring enabling event
Sequence Operation	Required	This is the final action

The Arm/Trigger subsystem starts with the IDLE state which occurs after a power-on, :ABORt, *RST, or a previous Arm/Trigger cycle has completed. When in the IDLE state, each of the lower levels is configured for their parameters. Some examples are:

SOURCE - The source of the enabling signal, i.e., BUS, EXTernal
SLOPe - Selects if an event occurs on POSitive or NEGative edges
COUNt - Specifies the number of times the ARMING will be true
ECOunt - Specifies the number of times the ARMING signal occurs before one true condition, etc.

After configuring all the layers, send the INITiate command to move into the INITIATED state. This then enables all lower layers to start their activity. Since each instrument uses different layers, consult the manual before programming. Look for a Trigger diagram and then look at the commands it references. Some examples using HP BASIC are as follows:

1. Take One Voltmeter Reading - This example uses the HP E1326 Multimeter

```
OUTPUT 70903;"CONF:VOLT:DC (@100)     ! Setup multimeter to take one reading
```


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```
OUTPUT 70903;"INIT;:FETCH?"          ! Initiate and read data
ENTER 70903;A                        ! Enter the reading
```

2. Function Generator is to Output 100 Cycles of a Waveform after an External Trigger - This example uses the HP E1340 Arbitrary Function Generator to output the waveforms after receiving a trigger signal on its "Aux In" port.

```
OUTPUT 70910;"ARM:STAR:LAY2:SOUR EXT;";   ! Arm source = Aux In port
OUTPUT 70910;"ARM:STAR:LAY2:COUN INF;";   ! Infinite number of Aux In arms
OUTPUT 70910;"ARM:STAR:LAY1:COUN 1e2"     ! Set for 100 cycles
OUTPUT 70910;"INIT"                       ! Enable everything to begin
```

Step 7: Check that Coupled Commands are Sent as a Group

Coupled commands are SCPI commands that have parameters which all must be sent to the instrument before they can be executed. This is necessary to transition from one set of parameters to another set. If coupled commands are not sent as one, the instrument generates a "Setting conflict" error.

To send coupled commands, each command must be separated by a semicolon. Once the coupled commands are sent, a normal Line Feed (LF), Line Feed with EOI, or an EOI should be sent to indicate the end of the coupled commands. Use the following two methods to send coupled commands in HP BASIC.

1. Send as separate commands, except disable the Line Feed with EOI by placing a semicolon at then end of the OUTPUT statement. Note that the last OUTPUT statement sends a Line Feed with EOI.

```
OUTPUT 70910;"SOUR:ROSC:SOUR INT;";
OUTPUT 70910;":SOUR:FREQ:MODE FSK;";
OUTPUT 70910;":SOUR:FREQ:FSK 10e3,20e3;"
OUTPUT 70910;":SOUR:FUNC:SHAP SIN;";
OUTPUT 70910;":SOUR:VOLT:LEV:IMM:AMPL 5V"
```

2. Send all commands in a single command string, shown as follows:

```
OUTPUT 70910;"SOUR:ROSC:SOUR INT;:SOUR:FREQ:MODE FSK;:SOUR:FREQ:FSK
10e3,20e3;:SOUR:FUNC:SHAP SIN;:SOUR:VOLT:LEV:IMM:AMPL 5V"
```

Step 8: Check for Command Synchronization

IEEE 488.2 specifies that all instruments have an input buffer and that execution of commands does not start until a program message terminator is received (i.e., Line Feed, Line Feed with EOI, or EOI). For a single instrument this causes no problems. However, if a single computer sends commands to more than one instrument, the second instrument may execute the commands before the first instrument executes the commands.

So synchronize instruments, send a command to the first instrument to output data. The computer then waits for the data to be returned before it sends the commands to the second instrument. A special IEEE 488.2

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command known as *OPC? was created to do this. This command outputs a "1" whenever the instrument has completed executing all previous commands.

The following is an example that closes relays on a switch module, waits for the command to complete, and then initiates a multimeter to make a measurement.

```
OUTPUT 70914;"CLOSE (@100,101,190);*OPC?"   ! Close the relays
ENTER 70914;A                               ! Wait for relays to close
OUTPUT 70903;"READ?"                        ! Make the measurement
```

Automating the Debugging Steps

The previous information defines a general process for debugging programs that control VXI SCP instruments. The following describes how to automate many debugging steps previously explained. The following uses a program that detects errors and displays the information you need to debug your program.

RN13_RMB Program

The "RN13_RMB" program used here uses HP BASIC as the program language. To fully understand this programming language, refer to the its manual. however, several of the important debugging features are highlighted when describing the theory of the "RN13_RMB" program. The program "RN13_RMB" has been developed for the HP E1306 Command Module and the HP E1326 5 1/2 Digit Multimeter. The program is available on the "Verification and Example Programs Disk" that came with the command module.

Using other Program Languages

The "Verification and Example Programs Disk" also contains the "RN13_RMB" program using other program languages and libraries. These include the following:

- Visual BASIC using the HP Standard Instrument Control Library (SICL) - RN13_VB.FRM program
- C/C++ using the HP Standard Instrument Control Library (SICL) - RN13_VC.C program
- C using the HP HP-IB Command Library - RN13_CC.C program
- QuickBASIC using the HP HP-IB Command Library - RN13_QBC.BAS program

Note that the C or C/C++ programs uses functions instead of subprograms to separate the different program operations.

Using the Program

The following shows how to use the program with your application code.

Step 1: Run Program Without Application Code

Run the program with no application code in Subprogram "Main". This verifies that you can successfully communicate with both the HP E1326 and the System instrument. If errors occur, calling Subprogram "E1300_stat", or pressing the softkey "SYS_STAT", shows information about all modules in the

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mainframe. The logical addresses along with the VXI information about the card will enable you to check that correct addresses are being used.

Step 2: Begin Writing the Application program

Begin writing your application in Subprogram "Main". The first thing you should always do is fully reset any instruments your application will be using. Lines 2250-2280 in Subprogram "Main" reset the HP E1326.

Step 3: Writing Your Application

Now write your application and then run the program. If your application terminates successfully, you will see the messages:

```
Checking for E 13xx Errors at the end of the program
SYSTEM ERROR +0,"No error"
DVM ERROR +0,"No error"
```

Program Description

In Subprogram "Main", lines 2300-2330 are the beginning of an application that written with an error in it to demonstrate the program's error handling. The error is in line 2310, as follows:

```
2310 OUTPUT @Dvm;"SAMP:COUNT5;:READ?"
```

When running the program, the resultant output shows this error:

```
ERROR 168 IN 2330 I/O timeout
DVM ERROR "Undefined header"
```

Next, the program automatically queried all of the HP E1326 command parameters and showed that:

```
SAMP:COUNT? = +1
```

Note that the I/O timeout in line 2320 was caused by an undefined header (i.e., incorrect SCPI command) in some command. The actual SAMP:COUNT is 1, not 5, as intended thus, the undefined header is probably in "SAMP:COUNT5". Consulting the manual on this command shows that a space is necessary between the "T" and the "5".

The second error:

```
DVM ERROR "Query UNTERMINATED"
```

is ignored because the process of querying for errors caused it. A "Query UNTERMINATED" error occurs any time a second query command (i.e., a command with a "?" in it) occurs before the data from the first is retrieved.

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Program Theory

Now that you have seen how to use this Debugging, ERROR and TIMEOUT handling program, the following explains some of the theory and mechanics of how it works.

Checking the Error Queue

In any VXI SCPI instrument, command errors such as syntax errors accumulate in the instrument's error queue. When an error is present in a command that is received, no action on that command is executed other than logging a message into the instrument error queue. Reading the error queue is critical because no visible indication of an error may be generated.

When the error queue has an error in it, the task is to discover which command caused it. Since most commands set parameters, when a command has a error, this parameter is not executed. A very effective debugging technique is to query previously sent commands for their current setting. When a queried setting doesn't match what you intended it to be, you have just located the error.

Using TIMEOUTS

Checking for errors after every command will find most errors. However, this decreases your overall system performance even after all bugs have been removed. Most errors in a program causes your application program to "hang up". Thus, TIMEOUTs are an excellent indication that an error has occurred. A strategy of checking for errors at the end of your program (or whenever your program hangs up) produces a program with no speed penalty and is very effective at finding errors.

This debugging technique is automated by the program "RN13_RMB". The shell program traps BASIC ERRORS and TIMEOUTS. It then queries for instrument errors, and if any occur, it reads and prints out the queries to its entire command set. It also does the error query at the very end of your application program. Use this information to compare the HP E1326 DMM state with the intended parameters.

For rapid debugging, you need to see program flow, program variables, instrument errors and instrument states. Making this all visible and easily accessible is the main advantage of a good DEBUGGING, ERROR and TIMEOUT handling shell such as "RN13_RMB".

Preventing Hang-Ups

The "Main" section of the program (lines 10-220) act as a shell that prevents your basic program from ever hanging up due to I/O that is not proceeding. It identifies the LINE NUMBER of lines that have RUN TIME ERRORS or that have TIMED OUT.

Lines 70 and 80, combined with placing all application code in a lower level context (Main), is what causes a TIMEOUT to be reported as an ERROR. BASIC ERRORS contain the line number whereas, TIMEOUTs do not. The BASIC ERRORS method provides the advantage of providing the line number of a TIMEOUT. The "ON TIMEOUT 8,3 GOTO End" interrupt branching can only occur if you are in the same context when the TIMEOUT occurs. Since all application code is in a lower level context (Main), this branch cannot be taken. Since this is a fatal condition, BASIC reports the timeout as a ERROR.

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Context levels in BASIC provide a level of interrupt flow control. In BASIC the interrupt destinations specified by GOSUB or GOTO are only taken when you are in the defining context. CALL or RECOVER destinations are branched to when in the current or lower level context. All lower level contexts inherit the interrupt specifications of the current context, however, lower contexts may freely redefine this. This allows application code starting in SUB Main to override the ON TIMEOUT and ON ERROR that are established in lines 70 and 80. However, if this is not done a very good default error handler is already in effect because of the inheritance.

Using the "E13xx_errors" Subprogram

When the shell detects an ERROR, it will call the subprogram "E13xx_errors". This queries instruments for errors. Querying instruments for errors is one of the most important steps in debugging I/O code. Often timeouts are caused by doing an ENTER after having sent incorrect commands to instruments. If the subprogram "E13xx_errors" detects any errors in an instrument, it also calls a routine that queries instruments for all of its command parameter values. You can use this information to help locate the bug.

To expand this shell to include more instruments, add the following:

1. ASSIGN a name and address to the new instrument i.e. lines 40, 50.
2. Place the new instrument name into the labeled common " COM /Instr".
3. Add an error reading loop for each instrument in the system (lines 300-380) into the subprogram "E13xx_errors".
4. Add a subprogram such as "E1300_stat" or "E1326_stat" that reads all of the command parameter values for the new instrument. Writing this program is an excellent way to become familiar with a new instrument.

Using "PAUSE", "Step", and "CONT"

Since the Shell prevents I/O hang ups, BASIC's PAUSE, STEP, and CONT may now be used effectively to debug programs. When a program doesn't seem to be proceeding correctly, use PAUSE then STEP to trace the flow. Type variable names to see their value when PAUSEd, and finally use CONT to proceed at full speed.

Using Softkeys

The following four softkeys to aid in debugging are provided as a feature of the main line of this program.

QUIT& ?	Checks for instrument errors and then stop.
END!	Ends the program immediately with no error checking.
SYS_STAT	Queries the System instrument for all command parameter settings and print out information on logical addresses in the system.
DVM_STAT	Queries the DMM instrument for all command parameter settings.

Starting the Application Code

Application code must start in the Subprogram "Main" for this shell to catch errors and time outs.

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Index

A

AC power fuse, installing, 1-3
Address, unique logical, 1-9
Address:
  logical, 1-9
  secondary HP-IB, 1-6 - 1-8
  setting plug-in module, 1-9
Addresses, determine logical, B-2
Addressing
  HP-IB, B-1
  logical, B-1
Addressing, HP-IB, 2-1
Analog bus cables, connecting, 1-13
Apply AC power, 1-16
Automating the Debugging Steps, B-7

B

BASIC, using HP, 2-13
Block, terminal, 1-1
Bus cables:
  analog bus, 1-13
  digital bus, 1-13

C

Cables:
  analog bus, 1-13
  connecting interface, 1-14
  connecting scanning multimeter, 1-13
  custom RS-232, 1-15
  digital bus, 1-13
  HP-IB, 1-14
  HP-IB, part numbers, 1-14
  RS-232, 1-15
Cardcage
  See mainframe
Caution:
  disconnect power before installing modules, 1-5, 1-12
  installing modules, vii
  static electricity, vii
Channels, scanned, 1-7
Checking:
  and setting the system time, 1-21
  for start-up errors, 1-20
  for system errors, 1-21
  the error queue, B-9
Closing channels on multiple modules, 1-8
Code, starting the application, B-11
Command errors, A-4
Command module, installing, 1-5
Commands, sending SCPI, 2-2
  C, 2-11
  C/C++, 2-6
  HP BASIC, 2-13
  Terminal, 2-15
  Visual BASIC, 2-3
Communication Between Mainframe And Computer. none, A-1
Communication, determining instrument, B-3
Compiling a program, C, 2-11
Config error 11. invalid instrument address, A-3
Config error 13. logical address or IACK switch set wrong, A-3
Configurations, instrument, 1-6
Configuring:
  scanning multimeter instrument, 1-7
  single module instruments, 1-6
  switchbox instrument, 1-8
Connecting the terminal, 2-15
Connecting:
  analog bus cables, 1-13
  HP-IB cable, 1-14
  interface cables, 1-14
  RS-232 cable, 1-15
  scanning multimeter cables, 1-13
  standby DC power, 1-17
Creating a scanning multimeter, 1-7
Creating a switchbox, 1-8
Custom cable, RS-232, 1-15

D

Data, example to read formatted C/C++, 2-9
Data, example to send and read formatted C/C++, 2-9
Data, example to send formatted C/C++, 2-9

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Data, program example to read unformatted C/C++, 2-8
Data, program example to send and read unformatted C/C++, 2-8
Data, program example to send unformatted C/C++, 2-8
Data, receiving, 2-2
  C, 2-11
  C/C++, 2-6 - 2-7
  HP BASIC, 2-13
  Visual BASIC, 2-3
Data, sending SCPI commands and receiving
  C/C++, 2-6
  Visual BASIC, 2-2
Data, using single functions to send and receive
  C/C++, 2-8
DC power:
  connecting, 1-17
Description, program, B-8
Determine:
  additional information, B-2
  instrument configurations, 1-6
  logical addresses, B-2
Determining instrument communication, B-3
Determining system information, B-2
Device driver not found warning, 1-18
Device drivers, downloading, 1-18
Device-Specific errors, A-4
Digital bus cables, connecting, 1-13
DOS, programs for, 1-19
Download device drivers, 1-18
Driver not found warning, 1-18
Drivers, downloading device, 1-18
DVM or DMM
  See multimeter

E

Error types, A-4
Error: 3: config warning. device driver not found, A-3
Errors:
  checking for start-up, 1-20
  checking for system, 1-21
Errors:
  command, A-4
  device-specific, A-4
  execution, A-4
  query, A-4
Example:
  programs, 2-1
  scanning multimeter instrument, 1-11
  single module instrument, 1-10
  switchbox instrument, 1-11
  to read formatted data C/C++, 2-9
  to send and read formatted data C/C++, 2-9
  to send formatted data C/C++, 2-9
Example program:
  C, 2-12
  HP BASIC, 2-14
  Visual BASIC, 2-4
Executing a program, C, 2-10
Execution errors, A-4

F

From the command line C/C++, 2-5
From the windows interface C/C++, 2-6
Fuse, installing, 1-3

G

Grounding and power warning, 1-16
Guidelines, logical address, 1-9

H

Hang-ups, preventing, B-9
How to run a program:
  C/C++, 2-5
  Visual BASIC, 2-2
HP E1326B Multimeter in scanning multimeter, 1-7
HP part numbers:
  HP-IB cables, 1-14
  RS-232 cables, 1-15
HP VIC, 1-1
HP-IB:
  addressing, 2-1
  cable part numbers, 1-14
  cable, connecting, 1-14
  command library, 2-10
  secondary address, 1-6 - 1-8

I

Identifier, instrument, 1-9
Information, determine additional, B-2
Information, determining system, B-2
Installation steps, 1-2
Installing modules caution, vii
Installing plug-in modules, 1-12
Instrument:

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configurations, determining, 1-6
identifier, 1-9
scanning multimeter, 1-11
single module, 1-10
switchbox, 1-11
Instruments:
scanning multimeter configuration, 1-7
scanning multimeter, configuring, 1-7
single module configuration, 1-6
switchbox configuration, 1-8
Interface cables, connecting RS-232, 1-15
Interface, from the windows C/C++, 2-6

L

Languages, using other program, B-7
Line power fuse, installing, 1-3
Listing, system error message, A-4
Logical address or IACK switch set wrong, A-3
config error, A-3
Logical address:
guidelines, 1-9
scanning multimeter, 1-11
setting plug- in module, 1-9
single module instrument, 1-10
switchbox instrument, 1-11
unique, 1-9
Logical and HP-IB addressing, B-1

M

Mainframe:
applying AC power, 1-16
connecting DC power, 1-17
installing fuse, 1-3
installing modules in, 1-12
rack mounting, 1-4
Measurements, scanned, 1-7 - 1-8
Menu, select instrument from an instrument, 2-16
Menu, select instrument from main, 2-15
Messages, A-2 - A-3
Modules:
allowed in scanning multimeter, 1-7
allowed in switchbox, 1-8
installing plug-in, 1-12
multiple module instruments, 1-7
scanning multimeter example, 1-11
single example, 1-10
single module instruments, 1-6
switchbox example, 1-11
unassigned, 1-9
Multimeter, scanning:, 1-11
creating, 1-7
Multiple module instruments, configuring, 1-7 - 1-8
Multiplexers:
allowed in switchbox, 1-8
as part of scanning multimeter, 1-7
grouping together, 1-8
Mux
See multiplexer

N

No Communication Between Mainframe And Computer, A-1

O

Open communication path
C/C++, 2-6
Visual BASIC, 2-3
Operation, verify, 1-19

P

Part numbers:
HP-IB cables, 1-14
RS-232 cables, 1-15
Path, open communication
C/C++, 2-6
Visual BASIC, 2-3
Plug-in module address setting, 1-10
Power and grounding warning, 1-16
Power applied:
caution, vii
warning, 1-3
Power fuse, installing, 1-3
Power, applying, 1-16
Preventing hang-ups, B-9
Program description, B-8
Program example
C, 2-12
HP BASIC, 2-14
Visual BASIC, 2-4
Program example to read unformatted data C/C++, 2-8
Program example to send and read unformatted data C/C++, 2-8
Program example to send unformatted data C/C++, 2-8
Program message terminator, B-3
Program theory, B-9
Program, compiling a C, 2-11
Program, executing a C, 2-10

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Program, how to run:
C/C++, 2-5
Visual BASIC, 2-2
Program, RN26_RMB, B-7
Program, Step 12A: verify using the VERF_XXX, 1-19
Program, step 12B: verifying using other than the VERF_XXX, 1-20
Program, using the, B-7
Programs:
example, 2-1
for DOS, 1-19
for windows, 1-20
steps to debug, B-1
supported C, 2-10
verification, 2-1
verification and example, 2-1
Protocol settings, RS-232, 1-15

Q

Query errors, A-4
Queue, checking the error, B-9
Queue, reading the error, A-3

R

Rack mounting the mainframe, 1-4
Reading the error queue, A-3
Receiving data, 2-2
C, 2-11
C/C++, 2-6 - 2-7
HP BASIC, 2-13
Visual BASIC, 2-3
RN26_RMB program, B-7
RS-232:
cable, connecting, 1-15
RS-232:
custom cable, 1-15
protocol settings, 1-15

S

Scanning DVM or DMM
See Scanning multimeter
Scanning multimeter example, 1-11
Scanning multimeter:, 1-11
connecting cables, 1-13
instrument, configuration, 1-7
multiplexers in, 1-7
Scanning voltmeter
See scanning multimeter
Scanning:
channels, 1-7
maximum rates, 1-13
measurements, 1-8
Schematic, RS-232 cable, 1-15
Secondary address, HP-IB, 1-7 - 1-8
Secondary address:
HP-IB, 1-6
Select instrument from an instrument menu, 2-16
Select instrument from main menu, 2-15
Sending SCPI commands, 2-2
C, 2-11
C/C++, 2-6
HP BASIC, 2-13
Terminal, 2-15
Visual BASIC, 2-3
Sending SCPI commands and receiving data
C/C++, 2-6
Visual BASIC, 2-2
Setting:
logical address, 1-10
plug-in module logical addresses, 1-9
Shock hazard warnings, vii
SICL
HP, 2-2, 2-5
using C/C++, 2-5
using visual basic, 2-2
Single module instrument example, 1-10
Single module instrument:
configuring, 1-6
example, 1-10
Softkeys, using, B-10
Standalone instruments, configuring, 1-6
Standby DC power, connecting, 1-17
Start-Up errors and messages, A-2
Starting the application code, B-11
Static electricity caution, vii
Step 2: rack mount the mainframe, 1-4
Step 3: install command module, 1-5
Step 4: determine instrument configurations, 1-6
Step 5: set plug-in module logical addresses, 1-9
Step 6: install plug-in modules, 1-12
Step 7: connect analog bus cables, 1-13
Step 8: connect interface cables, 1-14
Step 9: apply AC power, 1-16
Step 10: connect standby DC power, 1-17
Step 11: download device drivers, 1-18
Step 12: verify operation, 1-19
Step 12A: verify using the VERF_XXX program, 1-19
Step 12B: verifying using other than the VERF_XXX program, 1-20

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Step 1: install fuse, 1-3
Steps:
automating the debugging steps, B-7
installation, 1-2
to debug programs, B-1
Subprogram, using the "E13xx_errors", B-10
Supported C programs, 2-10
Switch
See also multiplexer
Switch modules allowed in switchbox, 1-8
Switchbox example, 1-11
Switchbox:
configuring, 1-8
logical addresses, 1-11
modules allowed, 1-8
multiple module, 1-8
single module, 1-8
System error message listing, A-4
System errors, A-3
System errors and messages, A-3
System time
checking, 1-21
setting, 1-21

T

Terminal block, 1-1
Terminal, connecting the, 2-15
Terminal, using a, 2-15
Terminator, program message, B-3
Theory, program, B-9
TIMEOUTS, using, B-9
Types, error, A-4

U

Unassigned module, 1-9
Unique logical address, 1-9
Using a terminal, 2-15
Using:
C and the HP-IB command library, 2-10
C/C++ and HP SICL, 2-5
HP BASIC, 2-13
other program languages, B-7
single functions to receive data C/C++, 2-8
single functions to send and receive data C/C++, 2-8
single functions to send data C/C++, 2-8
softkeys, B-10
the "E13xx_errors" subprogram, B-10
TIMEOUTS, B-9
visual BASIC and HP SICL, 2-2

V

Verification and example programs, 2-1
Verification programs, 2-1
VIC, 1-1
Virtual instrument
See scanning multimeter or switchbox

W

Warning:
device driver not found, 1-18
power and grounding requirements, 1-16
remove power cord, 1-3
shock hazards, vii
Warnings and cautions, vii
Windows, programs for, 1-20
Wiring, RS-232 cable, 1-15

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