HP 75000 SERIES C

21MHz Synthesized Function/Sweep Generator

HP E1440A

User's Manual

Enclosed is the User's Manual for the HP E1440A Function Sweep Generator Module. Insert this manual, plus any other VXIbus manuals that you have, into the binder that came with your Hewlett-Packard mainframe.

HEWLETT PACKARD

HP Part Number E1440-90011
Second Edition E0492
Printed in Germany, English

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21MHz Synthesized Function/Sweep Generator

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SERIAL NUMBERS

This manual applies to all instruments.

HEWLETT PACKARD

HP Part No. E1440-90011; Microfiche Part Number: E1440-95011
Printed in the Federal Republic of Germany, April 1992

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E0492

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Subject Matter

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Front Cover Photograph

The instrument photograph on the front cover shows the HP E1440A

Printing History

The Printing History shown below lists all Editions and Updates of this manual and the printing date(s). The first printing of the manual is Edition 1.

The Edition number increments by 1 whenever the manual is revised. Updates, which are issued between Editions, contain replacement pages to correct the current Edition of the manual. Updates are numbered sequentially starting with Update 1. When a new Edition is created, it contains all the Update information for the previous Edition. Each new Edition or Update also includes a revised copy of this printing history page. Many product updates or revisions do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

Control Serial Number: Edition 2 applies directly to all instruments.

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Safety Symbols

The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.

Indicates dangerous voltages.

Earth terminal.

Protective earth.

ATTENTION
Static Sensitive

Affixed to a product containing static sensitive devices - use anti-static handling procedures to prevent electrostatic discharge damage to components.

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The WARNING sign denotes a hazard. It calls attention to a procedure, practice or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

Caution

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(Federal Republic of Germany only)

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Hiermit wird bescheinigt, dass dieses Geraet/System HP E1440A, betrieben im HP 75000 Series C System in Uebereinstimmung mit den Bestimmungen von Postverfuegung 1046/84 funkentstoert ist.

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Introduction

This manual is arranged into five categories:

General Information
General descriptions of the equipment and preparation for use instructions - Chapters 1 and 2

Operating Information
Setting up and sample programs, programming techniques - Chapters 3 and 4

Programming Information
Explanation of each software command applicable to the HP E1440A - Chapter 5, Appendix B and Appendix D

Specifications
Appendix A

Customer Assistance
Sales and Service information: Appendix F.

Contents

B. Register Programming

C. Performance tests

F. Sales and Service Offices

Figures

Tables

1

Getting Started

Using this Chapter

This chapter introduces you to the VXIbus, HP E1440A Synthesized Function/Sweep Generator. The main sections of the chapter are:

General Description

The HP E1440A Synthesized Function/Sweep Generator is a multi-task signal generator, built as a C-size (double slot) plug-in module, for use with other similar modules in a VXI mainframe. It can be used as:

a reference source
Produces a sine wave of a specified frequency, amplitude, DC offset and phase.

a function generator
Produces various waveforms at a specified frequency, amplitude, DC offset and phase.

a sweep generator
Produces logarithmic and linear frequency sweeps.

Key Features

Key features of the HP E1440A are as follows:

- 5 different waveforms can be output
- Variable offsets and amplitudes
- Can be used as a DC source
- Multi-interval or multi-marker sweep capabilities
- Sweep sequencing
- Combined linear and logarithmic sweeps
- Phase-continuous sweep
- Message based module (responds to high level ASCII SCPI commands)
- Save/recall instrument settings
- Compatible with VXIbus mainframe unit and associated modules

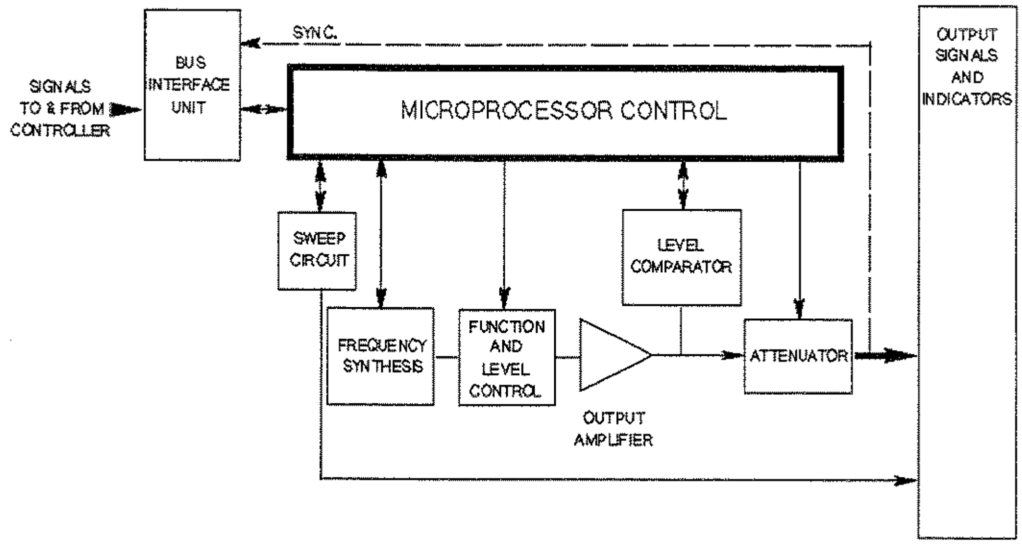

Figure 1-1. Block Diagram of the HP E1440A

Instrument Overview

The synthesizer is operated from a computer, using the Standard Commands for Programmable Instruments (SCPI) to communicate with it. There are no manual controls on the HP E1440A; only external connectors and indicator lamps.

The module has a unique logical address within the mainframe, which is allocated before use. The HP 75000 Series C System Installation Guide explains how to set this address. The guide should be your starting point towards using the synthesizer. Detailed information on setting up the address, is given in Chapter 2 *Configuring the HP E1440A* of this document.

Physical Description

The HP E1440A plug-in module occupies two C-size mainframe slots. It has a standard front panel providing BNC type electrical connectors and also indicator lamps. Inside the module there are two large printed circuit boards - the Control Board and the Synthesizer Board - mounted face to face on the outer rails of the module frame. These boards contain all the electronic components of the module and standard ribbon cables are used for inter-board connections. If the HP E1440A has the high voltage option fitted, the circuits for this are provided on a small daughter board fitted to the control board. Two rear, VXIbus edge connectors on the control board, carry all connections to the mainframe bus.

Introduction to Operation

This section contains information on checking communication between the synthesizer, mainframe and the computer. It includes information on returning the synthesizer to a known operating state (reset), should programming errors occur or if a restart is necessary.

Note

Before the HP E1440A can be used, some system configuration adjustments may need to be made to the module and then it has to be installed in the mainframe. Details of these tasks are given in Chapter 2 *Configuring the HP E1440A*.

Programming

The HP E1440A has been designed so that it can be controlled by an external computer. Its operations are therefore performed by a series of programmable commands using SCPI. There are no manual controls.

This section gives only brief general information on how to control the HP E1440A using a controller module. For a short form list of the commands specific to the HP E1440A, see Appendix D *Command Quick Reference*.

Programming information in this chapter is restricted to HP E1440A specifics, and assumes that you are familiar with VXIbus or VMEbus intrinsics.If you are not familiar with these, then refer to industry standard publications about the VMEbus and the following publications:

- The "VXIbus System Specification" published by The VXIbus Consortium, Inc.
- ANSI/IEEE-488.2-1987, "Digital Interface for Programmable Instrumentation" published by the Institute of Electrical and Electronic Engineers

A complete syntax list of the HP E1440A programming commands can be found in Chapter 5 *Command Syntax Reference*.

Self Test

Once the mainframe and module have been powered up (see Chapter 2 for instructions on how to check and set the module address), the synthesizer is ready for use. During power-up, the HP E1440A automatically executes an internal check and makes sure it is able to communicate with the back plane of the VXI mainframe.

Note

The HP E1440A has a "Failed" indicator that remains on if the synthesizer is not able to communicate with the controller.

This self test routine can also be executed on command and therefore sending the self test command is an easy way to check that you are correctly addressing the synthesizer. Self test is also useful in locating intermittent problems which might occur during operation.

The command used to execute self test is: *TST?

On execution of this command, the synthesizer performs a self test routine which is built into the module firmware. The result of the self test is placed in the error queue, which is subsequently interrogated by the controller.

The Error Queue

When an error occurs during operation, a suitable error code and message are stored in the synthesizer error queue. These errors can be read out using the 'SYS:ERR?'command. A returned value of 0 (zero) means there are no more errors. The error queue can store up to 30 codes and messages on a 'first in first out' (FIFO) basis. Error messages are described in Appendix E *Error Messages*

Sample program

The following BASIC program executes self test; this program assumes the mainframe is at a primary interface address of 09 and the synthesizer is at a secondary address of 11. The program also assumes that an HP 9000 Series 200/300 computer is used.

```
10  !Send the self-test command to the synthesizer
20  !
30  OUTPUT 70911;"*TST?"
40  !
50  !Enter and display the self test code
60  !
70  ENTER 70911;A
80  PRINT A
90  !
100  !Reset the synthesizer
110  !
120  OUTPUT 70911;"*RST"
130  END
```

Note

Last line of program
After testing, always reset the synthesizer to a known state.

Checking the Instrument Output

After using the above program to reset the HP E1440A, a simple test with an oscilloscope will check that the module is functional. Connect an oscilloscope to the output BNC and then send the following short program:

```
10  ! Set frequency value
20  !
30  OUTPUT 70911;"FREQ 1E3"
40  !
50  ! Set function to sinewave
60  OUTPUT 70911;"FUNC SIN"
70  !
80  ! Set output level to 1 V
90  !
100 OUTPUT 70911;"VOLT 1"
```

```
110 !
120 Switch on the output
130 !
140 OUTPUT 70911;"OUTP ON"
150 END
```

Reset

The module has a reset state which is entered once a reset command (*RST) has been received. The reset conditions are detailed in table 1-1.

Table 1-1. Instrument Reset State

Parameter	Reset State
INITiate:CONTinuous	OFF
Amplitude	1 mV (p-p)
DC Offset	0 V
Units	Volts
Frequency	0 Hz
Freq. Mode	FIXed
Start Frequency	0 Hz
Stop Frequency	21 MHz
Frequency Span - Hold	OFF
Frequency Span - Link	CENTer
Marker (n)	OFF (n is 1 to 9)
Marker Frequency (n)	0 Hz (n is 1 to 9)
Sweep Time	1 s
Automatic Sweep Trace	ON
Sweep Direction	UP
Reference Oscillator Source	INTernal
Reference Oscillator Automatic	ON
Function	SINe
AM State	OFF
PM State	OFF
Output	OFF
Output Amplifier (HV Opt 001)	OFF
TTL Trigger Output(n)	OFF (n is 0 to 7)
TTL Trigger Output, Source(n)	SYNC (n is 0 to 7)
Phase	0 Deg
Phase Step	1 Deg
Phase Units	Radians
*SAV(n)	(n is 0 to 9)

Front Panel Connections

The HP E1440A front panel is illustrated below

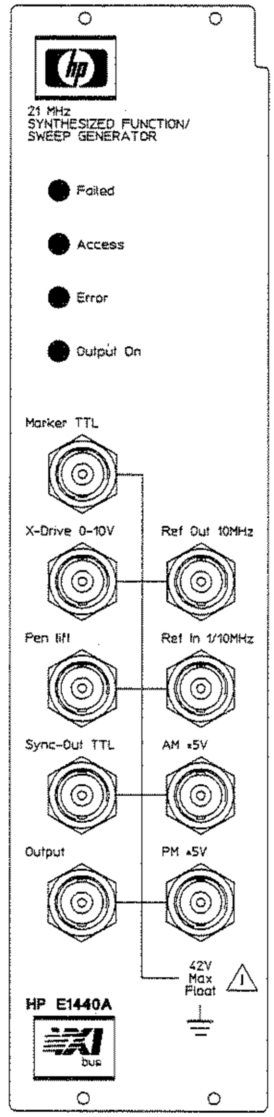

Figure 1-2. HP E1440A Front panel

Marker TTL

This TTL-compatible output goes low at the selected marker frequency during a sweep, and goes high at completion of the sweep, in the multi-interval mode. In the multi-marker mode the signal pulses low at the selected marker frequency.

X-Drive This output ramps from 0 V to 10 V during a sweep.

Pen lift This output provides a pen lift signal for a plotter at the end of a signal.

Sync-Out TTL A TTL compatible square wave synchronized output signal, is available at this connector. The signal is synchronized with the output signal crossover point (zero volts or DC offset voltage). The connector functions for frequencies up to 60 MHz.

Output Standard output impedance is 50Ω. High-voltage option (001) output impedance is nominally $< 3\Omega$ at DC, and $< 10\Omega$ at 1 MHz.

Ref Out 10MHz A 10 MHz signal from the HP E1440A reference circuits is available here.

Ref In 1/10MHz This external frequency reference may be used to phase-lock the internal 30 MHz oscillator.

AM (±5V) An Amplitude Modulation input reference can be connected here for input to the synthesizer circuit. Range is ±5 volts in all modes, i.e. sine, square, triangle, ramps.

PM (±5V) A Phase Modulation input reference can be connected here for input to the synthesizer circuit. Range is ±5 volts in all modes, i.e. sine, square, triangle, ramps.

Front Panel Indicators

Failed This red lamp illuminates as soon as power is applied to the module. The module then checks out it's connections to the VXIbus i.e. it checks that it is able to communicate with the mainframe. When that check is verified, the module extinguished the Failed lamp.

Note Absence of the **Failed** lamp does not necessarily mean that the module is suitable for use.

Access This green lamp flickers when the HP E1440A is in use, showing that communication between the module and mainframe is taking place.

Error This red lamp illuminates to indicate there are error codes queued in the store, ready for collection by the controller.

Output On This green lamp illuminates when there is a signal available at the output connector.

Caution

The outputs and externally applied voltages may be floating at upto 42 V. Risk of electric shock may exist

The input/output connectors should not be subjected to overload. Carefully note the max. applicable voltage for each connector as specified in Appendix A to this manual.

2

Configuring the HP E1440A

Using this Chapter

This chapter provides instructions on preparation for use and how to install the HP E1440A module. It also includes information about initial inspection and damage claims, packaging, storage and shipment.

Before operation, the instrument and manual, including the red safety page, should be reviewed for safety markings and instructions. These must then be observed to ensure safe operation and to maintain the instrument in safe condition.

Inspection

Inspect the shipping container for damage. If the container or cushioning is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been verified both mechanically and electrically.

Procedures for checking the operation of the instrument are given in Chapter 1 *Getting Started*. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the nearest Hewlett-Packard office. Keep the shipping materials for carrier's inspection. The HP office will arrange for repair or replacement without awaiting settlement.

Warning

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, etc.).

Claims and Repackaging

If physical damage is evident or if the instrument does not meet specification when received, notify the carrier and the nearest Hewlett-Packard Service Office. The Sales/Service Office will arrange for repair or replacement of the unit without waiting for settlement of a claim against the carrier.

Storage and Shipment

The instrument can be stored or shipped at temperatures between −40°C and +75°C. The instrument should be protected from temperature extremes which may cause condensation within it.

Return Shipments to HP

If the instrument is to be shipped to a Hewlett-Packard Sales/Service Office (see Appendix F), attach a tag showing owner, return address, model number and full serial number and the type of service required.

The original shipping carton and packing material may be re-usable, but the Hewlett-Packard Sales/Service Office will also provide information and recommendations on materials to be used if the original packing is no longer available or reusable. General instructions for repacking are as follows:

1. Wrap instrument in heavy paper or plastic.
2. Use strong shipping container. A double wall carton is adequate.
3. Use enough shock-absorbing material (3 to 4 inch layer) around all sides of the instrument to provide a firm cushion and prevent movement inside container.
4. Seal shipping container securely.
5. Mark shipping container **FRAGILE** to encourage careful handling.
6. In any correspondence, refer to instrument by model number and serial number.

Configuration

As detailed in the VXIbus Mainframe *System Installation Guide*, each plug-in module has a row of switches which are used to set the logical address of the module. The mainframe operating system uses these unique addresses, to combine different modules into virtual instruments within the mainframe slots. The module is addressed by the computer program, using the logical address to distinguish it from other modules in the system.

ATTENTION
Static Sensitive

ATTENTION STATIC SENSITIVE Handle the module, only at 'Static Safe' work stations !

The Logical Address Switch

Figure 2-1 shows the location of the HP E1440A logical address switch. Access to alter the switch settings may be gained through a cutout in the module cover.

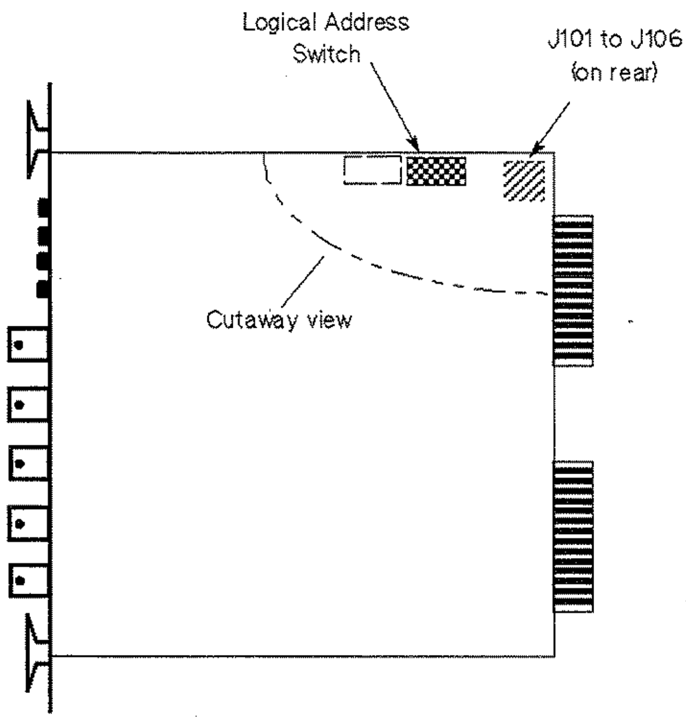

Figure 2-1. Address Switch and Jumper Location

The Logical Address switch has a factory setting of 88 which is equivalent to a secondary address of 11.

Figure 2-2 shows how a primary address setting of 88, transposes to a secondary address of 11 by shifting three places (ignoring the first three switches). Make sure you apply this rule when altering the switch setting to a number of your choice. Remember, the module secondary address must be the one present in all control programs for this module.

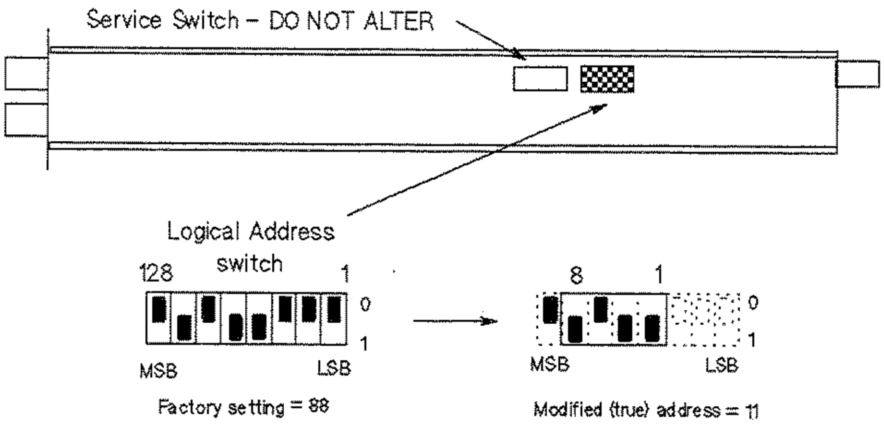

Figure 2-2. Address Switch Settings

This view of the switch settings is the one you will see when looking directly into the top of the module. The switch positions are shown from the same viewpoint.

Note

If there is no other identical HP E1440A module in the mainframe with this address, and this factory set address does not conflict with one of the other modules, then the factory setting may be left as it is set.

⚠

The service switch beside the logical address switch is factory set as shown and is for use by service personnel only. It must not be altered!

Changing Module Settings

On the left hand side, close to the VXIbus connectors, mounted on the circuit land side of the control printed circuit board, there are several connecting links which you can change to alter the module configuration for control interrupt priority. The link locations are shown on Figures 2-1, 2-2 and configurations are shown on Figure 2-3. Access is gained through a cutout in the cover.

Jumpers J101 to J106 can be used to alter the interrupt priority setting of the HP E1440A module. In most cases this would not need to be altered from the factory setting of BG/BR3. However, if the HP E1440A is being used in a mainframe with other non-HP instruments, or in a specialized test equipment set-up, there may be a requirement to alter the controller interrupt priority of the module. Proceed as follows:

Caution

When altering the BG/BR level you will touch electronic components. **ESD precautions** such as a wristlet connector to module cover, must be used. Do not use BNC outer shields they are not ground!

1. Place module on a bench with the jumper access cutout uppermost
2. Refer to figure 2-3 and remove the single jumper from the column where you want the full column jumpered according to the BG/BR level you require
3. Move the three jumpers that are together, across to the column you have just emptied
4. Place the single jumper in the vacated column in line with the other two single jumpers
5. Check that the final jumper positions are correct for the BG/BR level you require and that all jumpers are secure on their pins

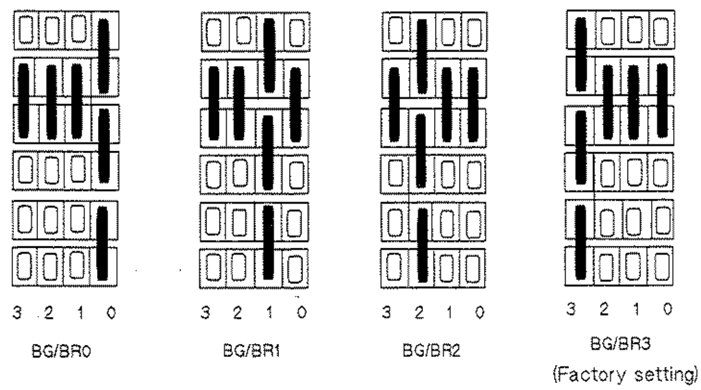

Figure 2-3. Jumper J101 Links Settings

The Jumper positions are factory set as shown. Do not alter unless absolutely necessary.

Installation

In addition to C-Size modules, the mainframe also accepts A- and B-Size modules. If you intend using the HP E1440A with these smaller size modules, it is better to install them first. Refer to the mainframe manual for details.

Warning

SHOCK HAZARD. Remove all sources of power from the mainframe before removing or installing the HP E1440A module.

ATTENTION
Static Sensitive

ATTENTION STATIC SENSITIVE Handle the module, only at 'Static Safe' work stations !

Installing the HP E1440A

Choose the mainframe location for the module and place the module card edges into the front mainframe guides (top and bottom). Fit the module as follows:

- Slide the module towards the rear of the mainframe until the connectors approach the backplane
- Check that the module connectors align with the backplane receptacles

Caution

There are DIL switches on the backplane beside the connector receptacles, which could be damaged or altered, if the module connectors are pushed against them

- Carefully push the module home so that the connectors mate solidly with the back plane receptacles, the screening fingers rest comfortably against the adjacent module, and the front panel is flush against the front bar of the mainframe
- Secure the module using the captive screws in the front panel to lock the module into the mainframe

Power can now be restored to the mainframe.

3

Using the HP E1440A

Using this Chapter

The purpose of this chapter is to provide example programs that show you how to operate the synthesizer. With minor modifications, these programs can also be used for many of your applications. The examples in this chapter include:

Sample Programs

This chapter provides only basic programming information for the HP E1440A. More advanced examples may be found in Chapter 4 *Understanding the HP E1440A*

After power-on of the VXI mainframe, check that the **Failed** lamp on the HP E1440A front panel, has extinguished. This means that the microprocessor within the unit, has checked that it is connected properly to the VXIbus and can operate with the rest of the system.

To check if the controller and the HP E1440A are talking with each other, send a query and look at the response from the HP E1440A. For example:

Program	Result
10 `DIM A$[255]`	Dimensions A$.
20 `OUTPUT 70911; ":FUNC?"`	Queries the type of output waveform the HP E1440A is set to.
30 `ENTER 70911;A$`	The HP E1440A waveform type is received by the controller.
40 `PRINT A$`	The type is displayed.
50 `END`	Program end.

The display should read SIN (Sine wave) because after a reset, that is what the HP E1440A is set to.

Note

Whilst messages (Command strings and responses) are being exchanged between the HP E1440A and the controller, the **Access** lamp will flash intermittently on the front panel.

If the function is not shown, the first thing to check is that the address set on the HP E1440A is the same as the one you are using (in this case 11). Details of address set up are given in Chapter 2 *Configuring the HP E1440A*.

Typical Commands

Any commands shown here in square ([ ]) brackets, are optional. They are included to help your understanding of the command logic.

[:SOURce]:OUTPut Command

The [:SOUR]:OUTP ON/OFF command is used to switch a relay that applies the instrument output signal to the output connector, or isolates the connector. The command switches the output signal.

:ROSCillator Command

The HP E1440A may use alternative reference oscillators as follows:

Source Keyword	Description
:ROSC:SOUR INTernal	An internal 30 MHz crystal
:ROSC:SOUR EXTernal	A reference input to the front panel connector in the range 1 MHz to 10 MHz
:ROSC:SOUR CLK 10	A 10 MHz signal taken from the VXIbus (available to all mainframe modules)

FUNC Command

The function, FUNC[:SHAPe], command allows you to set the shape and frequency of your waveform.

Table 3-1. Values for FUNC Command

Function	Range
DC	DC level
SINusoid	1 μHz to 21 MHz
SQUare	1 μHz to 11 MHz
TRIangle	1 μHz to 11 kHz
RUP (Pos. slope ramp)	1 μHz to 11 kHz
RDOWn (Neg. slope ramp)	1 μHz to 11 kHz
TTL	1 μHz to 60 MHz

FREQ Command

The frequency sweep controls are as follows:

Table 3-2. Frequency Controls

Control	Range
:MODE	CW, FIXed, SWEep or LIST
:STARt	numeric value sets start frequency
:STOP	numeric value sets stop frequency
:CENTer	numeric value sets center frequency
:SPAN	numeric value sets frequency span

Note

Changing the span alters the start and stop frequencies but not center

Programming Examples

The following sections give programming examples for the HP E1440A. The examples are divided into three different sections, a simple function generator, a multi-interval sweep generator and a multi-marker sweep generator. All of the programs assume the following:

- an HP 9000, Series 200 or 300 Computer as controller
- that BASIC is the programming language
- that the HP E1440A is preset to HP-IB address 11
- that the slot 0 commander (E1405) is set to primary HP-IB address 9

Function Generator

The following program shows an example of how to program the HP E1440A as a function generator. The program shows how to:

1. Clear all devices (resets E1440A)
2. Set the waveform as a square wave
3. Set the frequency to 10 kHz
4. Set the amplitude to 1 V(p-p)
5. Set the DC offset to 4.5 V
6. Set the phase to 45°
7. Switch the output on

Program	Result
10 OUTPUT 70911; "*RST;*CLS"	Clears all status registers.
20 OUTPUT 70911; ":SOUR:FUNC SQU"	selects square wave
30 OUTPUT 70911; ":FREQ 10000"	sets frequency to 10 kHz
40 OUTPUT 70911; ":VOLT 1"	sets amplitude to 1 volt
50 OUTPUT 70911; ":VOLT:OFFS 4.5"	sets offset to 4.5 volts
60 OUTPUT 70911; ":PHAS 45 DEG"	sets phase to 45°
70 OUTPUT 70911; ":OUTP ON"	switches output signal to the front panel BNC connector
80 END	Program end.

Note

Lines 20 to 70 could have been sent as one composite instruction
`OUTPUT 70911; ":SOUR:FUNC SQU;:FREQ 10000;:VOLT 1;:VOLT:OFFS 4.5;:PHAS 45 DEG"`

Multi-Interval Sweep Generator

The following program shows an example of how to program the HP E1440A as a multi-interval sweep generator. The program assumes that the amplitude, waveform, DC offset and phase, are the same as set in the previous example, retrace time is set to 5 seconds and the sweep is to run continuously. The program then shows how to set five sweep intervals with the following parameters:

Interval 1:	start frequency	1 kHz
	stop frequency	3 kHz
	marker frequency	2 kHz
	sweep time	1 sec.
	sweep mode	linear
Interval 2	start frequency	500 Hz
	stop frequency	10 kHz
	sweep time	1 sec.
	sweep mode	logarithmic
Interval 3	start frequency	2 kHz
	stop frequency	4 kHz
	marker frequency	3 kHz
	sweep time	1 sec.
	sweep mode	linear
Interval 4	start frequency	900 Hz
	stop frequency	10 kHz
	sweep time	1 sec.
	sweep mode	logarithmic
Interval 5:	start frequency	3 kHz
	stop frequency	5 kHz
	marker frequency	4 kHz
	sweep time	1 sec.
	sweep mode	linear

```
10  OUTPUT 70911; ":LIST:FREQ:STAR 1000,500,2000,900,3000"
20  OUTPUT 70911; ":LIST:FREQ:STOP 3000,10000,4000,10000,5000"
30  OUTPUT 70911; ":LIST:FREQ:MARK 2000,200,3000,500,4000"
40  OUTPUT 70911; ":LIST:FREQ:MARK:STAT ON,OFF,ON,OFF,ON"
50  OUTPUT 70911; ":LIST:FREQ:SPAC LIN,LOG,LIN,LOG,LIN"
60  OUTPUT 70911; ":LIST:DWELL 1"
70  OUTPUT 70911; ":SWE:RTIM 5"
80  OUTPUT 70911; ":LIST:SEQ (1:5)"
90  OUTPUT 70911; ":FREQ:MODE LIST"
100 OUTPUT 70911; ":INIT:CONT ON"
110 END
```

Multi-Marker Sweep Generator

The following program shows an example of how to program the HP E1440A as a multi-marker sweep generator. The program sets up the following continuous sweep:

Interval Start Frequency	1.0 kHz
Interval Stop Frequency	5.0 kHz
Interval Sweep Time	1.0 s

with the following markers:

Marker 1	1.5 kHz
Marker 2	2.0 kHz
Marker 3	2.5 kHz
Marker 4	3.0 kHz
Marker 5	3.5 kHz
Marker 6	4.0 kHz
Marker 7	4.5 kHz

```
 1 OUTPUT 70911;":FREQ:STAR 1E3"
 2 OUTPUT 70911;":FREQ:STOP 5E3"
 3 OUTPUT 70911;":MARK1:FREQ 1.5E3;:MARK2:FREQ 2E3"
 4 OUTPUT 70911;":MARK3:FREQ 2.5E3;:MARK4:FREQ 3E3"
 5 OUTPUT 70911;":MARK5:FREQ 3.5E3;:MARK6:FREQ 4E3"
 6 OUTPUT 70911;":MARK7:FREQ 4.5E3"
 7 OUTPUT 70911;":MARK1:STAT ON;:MARK2:STAT ON"
 8 OUTPUT 70911;":MARK3:STAT ON;:MARK4:STAT ON"
 9 OUTPUT 70911;":MARK5:STAT ON;:MARK6:STAT ON"
10 OUTPUT 70911;":MARK7:STAT ON"
11 OUTPUT 70911;":SWE:TIME 1"
12 OUTPUT 70911;":FREQ:MODE SWE"
13 OUTPUT 70911;":INIT:CONT ON"
14 END
```

Using the Command Group Feature

This example program in RMBASIC (Rocky Mountain BASIC), demonstrates the benefits of the 'Command Group Feature' implemented in the E1440 See Chapter 4 *Understanding the HP E1440A*.

The :VOLT and :VOLT:OFFSet commands are used as an example and the measurement task is :

Base setup:

Frequency :	11 MHz
Function :	SIN

First measurement:

Voltage :	0.1 V
Voltage offset :	0.2 V

Second measurement:

Voltage :	2.0 V
Voltage offset :	3.0 V

Third measurement:

Voltage :	0.1 V (again
Voltage offset :	0.2 V (again)

The problem here is that, if parameters are programmed in separate output statements, you would enter temporarily incompatible states. Referring to the example above, if you always program in the order :VOLT and then :VOLT:OFFS, you will get an error at the beginning of the third measurement because an offset of 0.1 V is incompatible with an amplitude of 2 V (leftover from second measurement).

Reverting the order of programming (first offset then amplitude) will just move the problem, not eliminate it. In this case you will get an error at the first :VOLT:OFFS command because an offset of 0.1 V is incompatible with an amplitude of 0.001 (value after *RST).

There are three ways out of the dilemma :

1. Every time you want to program amplitude and offset set them to save values first. This doubles the programming effort.
2. Keep track of the current value and select programming sequence (amplitude/offset or offset/amplitude) accordingly. Very time consuming.
3. Send amplitude and offset in one string. The most efficient method.

Sample program

```
10    REAL E1440              ! for the instrument HP-IB address.
20                            ! Note that an INTEGER is too small to hold
30                            ! a HP-IB address with secondary addressing.
40    !
```

```
50   E1440=70911               ! assumed slot 0 commander is connected to
60                             ! HP-IB interface with select code 7,
70                             ! primary HP-IB address of slot 0 commander is 9
80                             ! and logical address of E1440 is 11 (secondary
90                             ! HP-IB address is logical add. shifted left 3 bits)
100   !
110   ! At the start we put instrument into a known state.
120  CLEAR E1440
130  OUTPUT E1440;"*RST; :STATUS:PRESET; *CLS"
140   !
150   ! Base setting
160   !
170  OUTPUT E1440;":FUNC SIN; :FREQ 11 MHZ; :OUTP ON"
180   !
190   ! Setup 1
200   !
210   OUTPUT E1440;":VOLT:AMPL 0.1 V; OFFSET 0.2 V"
220   !
230   ! Do measurement 1
240   !
250   OUTPUT E1440;":VOLT:AMPL 2.0 V; OFFSET 3.0 V"
260   !
270   ! Do measurement 2
280   !
290   OUTPUT E1440;":VOLT:AMPL 0.1 V; OFFSET 0.2 V"
300   !
310   ! Do measurement 3
320   !
330   END
```

Using *OPC? to Synchronize the HP E1440A

This example program demonstrates the use of the *OPC? to synchronize the controller with the E1440. It also shows how one can deal with the LIST subsystem which can sometimes be slightly unwieldy.

The requirement is to set up a list sweep comprising:

- one lin interval 1 MHz to 13 MHz , 1 second
- one equi interval 13 MHz to 13 MHz , 2 seconds
- one lin interval 13 MHz to 1 MHz , 1 second
- one log interval 1 MHz to 13 MHZ , 3 seconds

Output function is SIN, amplitude is 5 V.
When the sweep stops we will print the message *List sweep finished* on the computer screen

Note We will not program markers because we do not need them.

After *RST the LIST:FREQ:MARK:STAT list contains one entry with the value OFF. This entry can be thought of as being replicated as many times as imposed by the other non-singular lists. We will store the parameters in data lines.

The first data line is the sweep sequence as a string and the number of intervals is defined by the succeeding data lines.

```
10 List_data:   !
20   !
30   DATA "(1:4)",4
40   !
50   ! The following 4 data lines contain :
60   ! start , stop , "spacing" , time
70   DATA 1E6 , 13E6 , "LIN" , 1
80   DATA 13E6 , 13E6 , "LIN" , 2
90   DATA 13E6 , 1E6 , "LIN" , 1
100   DATA 1E6 , 13E6 , "LOG" , 3
110   !
120   ! some variables
130   !
140   ! first the arrays for the list parameters
150   !
160   REAL Lstart(1:10)       ! start frequencies
170   REAL Lstop(1:10)        ! stop frequencies
180   REAL Ltime(1:10)        ! dwell times
190   DIM Lspac$(1:10)[5]     ! spacing modes
200   DIM Lseq$[80]           ! sequence
210   DIM Opc_resp$[3]        ! for entering the *OPC? response
220   !
230   INTEGER I               ! the famous all purpose I
240   INTEGER No_of_int       ! number of intervals
250   !
260   REAL E1440              ! for the instruments HP-IB address.
270                           ! Notice that an INTEGER is too small to hold
280                           ! a HP-IB address with secondary addressing.
290   !
300   E1440=70911             ! assumed slot 0 commander is connected to
310                           ! HP-IB interface with select code 7,
320                           ! primary HP-IB address of slot 0 commander is 9
330                           ! and logical address of E1440 is 11 (secondary
340                           ! HP-IB address is logical add shifted left 3 bits)
350   !
360   ! lets fill the parameter arrays first
370   !
380   RESTORE List_data       ! not necessary in a program as short as this
```

```
390                            ! but always good style.
400  READ Lseq$,No_of_int
410  !
420  FOR I=1 TO No_of_int
430    READ Lstart(I),Lstop(I),Lspac$(I),Ltime(I)
440  NEXT I
450  !
460  ! To start with, we put instrument into known state.
470  CLEAR E1440
480  OUTPUT E1440;"*RST; :STATUS:PRESET; *CLS"
490  !
500  ! Setup the list
510  !
520  OUTPUT E1440;":LIST:FREQ:START ";        ! mind the ';'! it suppresses
530                                           ! the <CR/LF> at the end of
540                                           ! the output statement.
550                                           ! also watch the space ' '
560                                           ! after START
570  ! now output the parameters in a loop
580  FOR I=1 TO No_of_int
590    OUTPUT E1440;Lstart(I);
600    IF I<No_of_int THEN OUTPUT E1440;","; ! insert ',' if not last param.
610  NEXT I
620  OUTPUT E1440;";"         ! output ';<CR/LF>' at end of list
630  !
640  ! now we do the same as above for stop, spacing and dwell list.
650  !
660  OUTPUT E1440;":LIST:FREQ:STOP ";
670  FOR I=1 TO No_of_int
680    OUTPUT E1440;Lstop(I);
690    IF I<No_of_int THEN OUTPUT E1440;",";
700  NEXT I
710  OUTPUT E1440;";"
720  !
730  OUTPUT E1440;":LIST:FREQ:SPAC ";
740  FOR I=1 TO No_of_int
750    OUTPUT E1440;Lspac$(I);
760    IF I<No_of_int THEN OUTPUT E1440;",";
770  NEXT I
780  OUTPUT E1440;";"
790  !
800  OUTPUT E1440;":LIST:DWELL ";
810  FOR I=1 TO No_of_int
820    OUTPUT E1440;Ltime(I);
830    IF I<No_of_int THEN OUTPUT E1440;",";
840  NEXT I
850  OUTPUT E1440;";"
860  !
870  ! last but not least the sequence
880  !
890  OUTPUT E1440;":LIST:SEQ ";Lseq$
```

```
900  !
910  ! The lists are in the box -- base setting
920  !
930  OUTPUT E1440;":FUNC SIN; :VOLT 5 V; :OUTP ON"
940  !
950  ! set instrument in list mode and initiate one sweep cycle
960  !
970  OUTPUT E1440;":FREQ:MODE LIST; :INIT"
980  !
990  ! issue *OPC? command and read response.
1000  ! the response will not be sent by the E1440 until the currently
1010  ! running sweep stops.
1020  ! note that this may cause an I/O timeout on the controller if
1030  ! timeout is set too short for the HP-IB interface.
1040  !
1050  OUTPUT E1440;"*OPC?"
1060  ENTER E1440;Opc_resp$
1070  !
1080  ! ready, print the message and end
1090  !
1100  PRINT "List sweep finished"
1110  !
1120  END
```

Using *WAI to Synchronize the HP E1440A

This example RMBASIC program demonstrates the use of the *WAI command to synchronize commands with the overlapping sweep operation of the E1440

Note that we do NOT synchronize the controller with the HP E1440, for that You need *OPC or *OPC?

The requirement is to set up a sweep with the following parameters:

Start frequency	1.33 MHz
Stop frequency	4.5 MHz
Sweep time	1 sec
Function	SIN

and we want to have the following dynamic operation :

- output is off
- switch output on and do one sweep cycle with an amplitude of 3 volts.
- do one sweep cycle with an amplitude of 6 volts.
- do one sweep cycle with an amplitude of 9 volts and switch output off.

```
10   REAL E1440              ! for the instruments HP-IB address.
20                           ! Note that an INTEGER is too small to hold
30                           ! a HP-IB address with secondary addressing.
40   !
50   E1440=70911             ! assumed slot 0 commander is connected to
60                           ! HP-IB interface with select code 7,
70                           ! primary HP-IB address of slot 0 commander is 9
80                           ! and logical address of E1440 is 11 (secondary
90                           ! HP-IB address is logical add, shifted left 3 bits)
100   !
110   ! To start with, we put instrument into a known state.
120   CLEAR E1440
130   OUTPUT E1440;"*RST; :STATUS:PRESET; *CLS"
140   !
150   ! Base setting
160   !
170   OUTPUT E1440;":FUNC SIN; :FREQ:START 1.33 MHZ; STOP 4.5 MHZ; :SWEEP:TIME 1"
180   !
190   ! Set first amplitude and set instrument into sweep mode (notice
200   ! that output is still off)
210   !
220   OUTPUT E1440;":VOLT 3; :FREQ:MODE SWEEP"
230   !
240   ! Switch output on an init one sweep cycle
250   !
260   OUTPUT E1440;":OUTP ON; :INIT"
270   !
280   ! Wait for completion of the sweep cycle, set amplitude and init next cycle
```

```
290   !
300   OUTPUT E1440;"*WAI; :VOLT 6; :INIT"
310   !
320   ! Last cycle
330   !
340   OUTPUT E1440;"*WAI; :VOLT 9; :INIT"
350   !
360   ! Wait for completion of last sweep cycle and switch output off
370   !
380   OUTPUT E1440;"*WAI; :OUTP OFF"
390   !
400   END
```

4

Understanding the HP E1440A

Using this Chapter

This chapter describes the main features of the synthesizer and how they are used. It provides an extension to information contained in Chapter 3 *Using the HP E1440A* and describes additional features and techniques by extending the user's understanding of the instrument. The main sections of this chapter are as follows:

A System Overview

The E1440A Synthesizer consists of five main sub-units as follows:

1. **VXIbus Interface**
2. **Microprocessor System**
3. **Synthesizer**
4. **Function Generator**
5. **Output Unit**

These units are illustrated in Figure 4-1 below.

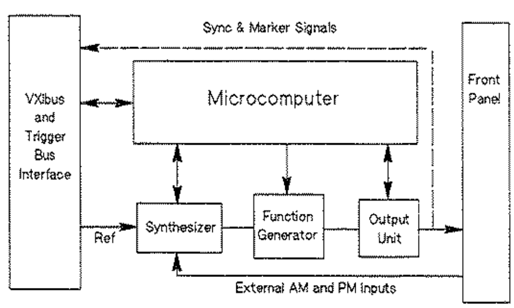

Figure 4-1. Simplified Block Diagram

The VXIbus Interface

The interface allows the VXI mainframe controller to communicate with the HP E1440A. It accepts Standard Commands for Programmable Instruments (SCPI) from the controller and converts the commands (via a resident interpreter) into a form the HP E1440A understands. The interface also passes information obtained from the HP E1440A back to the controller system.

Included in the interface, is the power supply (a DC-DC Converter) module which takes it's supply from the mainframe bus and converts it into the supplies required by the HP E1440A. In doing so it also isolates the HP E1440A from the mainframe bus, thus filtering out external noise and possible voltage variations.

The Microprocessor System

This part of the HP E1440A includes the microprocessor, associated ROM and RAM areas, decoders and peripheral devices. It maintains overall control of the whole unit.

The Synthesizer

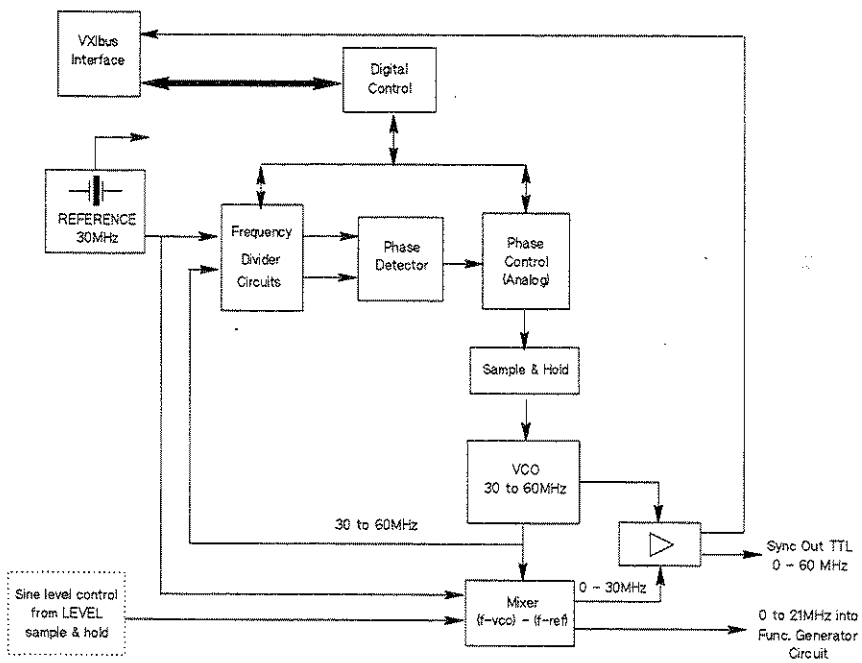

Figure 4-2. Synthesizer Block Diagram

The synthesizer produces basic reference frequencies for the external outputs. To do this it uses a crystal source reference frequency (30 MHz) and applies mathematical, phase detection, averaging techniques etc. to produce an output from a voltage controlled oscillator. Overall control of the synthesizer circuits is exercised by a digital control unit, slaved to the HP E1440A microprocessor.

The Function Generator

The Function Generator takes synthesizer outputs and combines them into composite signals of various types, for output. To produce composite signals it generates up two source waveforms, sine and triangular. The sine wave is operated upon if necessary, to convert into a square wave. Filtering and current buffering are carried out by the function generator.

The Output Unit

This unit consists of several sub units, including the HP E1440A front panel.

Amplifier

The amplifier takes the function generator output, synchronizes it with the set requirements and amplifies the signal to the required levels.

Attenuator

The attenuator circuit buffers the HP E1440A from external loads imposed by the UUT, ensures that output signals are of the correct impedance, and applies a multiplication factor if required.

Sweep Generator

This circuit generates control signals required by external equipment such as plotters and chart recorders, that require synchronization and markers for subsequent analysis of traces. A normal test requirement would be for test frequencies generated by the HP E1440A, to be applied to the unit under test (UUT), and it's output recorded by a plotter or recorder. In these cases it is necessary to show the exact relationships including timing, between application of the input to the UUT and the output characteristics of the UUT.

Front Panel

The front panel carries four indicator lamps and nine BNC input/output connectors. The identity and function of these are described in Chapter 1 *Getting Started*. Some of the outputs are also made available to the back plane trigger bus.

Planning and Programming

All operations performed by the HP E1440A are carried out in response to computer program instructions. The user is therefore forced to accept a method of use, that is imposed by the need to plan requirements of the HP E1440A and implement them. This means that when a test procedure is available, all the test requirements and numerous sequential changes in control settings for the synthesizer, must be written and assembled into a logically sequenced program. Preferably flow charted.

Note

With conventional test equipment the approach is less disciplined, because in most cases a user can pause in the task, manually reset and select alternative control settings as required by the test procedure he is following, and then continue.

Description of available programming commands and their syntax notation, are provided in Chapter 5 *Command Reference*. Some sample programs are provided here and in Chapter 3 *Using the HP E1440A*. The following paragraphs of this chapter, should help you to correlate commands with the separate facilities of the HP E1440A.

The HP E1440A in a Test Environment

This section describes features of the instrument and the commands used to control those features.

Signal Parameters

The Parameter commands FREQuency, AMPLitude, OFFSet and PHASe enable you to set the frequency, amplitude, DC offset and phase values, respectively, of your output signal.

FREQuency

The command is [:SOURce]:FREQ followed by a numerical value representing the number of cycles per second (Hz). For example 10 for 10 Hz and 10000 for 10 kHz

Resolution of the frequency value is 1 μHz for frequencies up to 99,999.999 999 Hz, independent of the waveform selected, and from 1 MHz upwards the resolution is 100 mHz. The frequency range is dependent on the waveform selected. During a frequency change, the main output is phase-continuous; that is, there are no phase discontinuities in the output waveform.

Table 4-1. Frequency Ranges

Function	Range
SINE WAVE	1 μHz to 21 MHz
SQUARE WAVE	1 μHz to 11 MHz
TRIangle	1 μHz to 11 kHz
RUP (Pos. slope ramp)	1 μHz to 11 kHz
RDOWn (Neg. slope ramp)	1 μHz to 11 kHz
TTL/Aux	1 μHz to 60 MHz

High-Voltage Option (Output Amplifier :OUTPut:AMPLify)

When the high-voltage output is used (option 001 is installed), the load resistance must be greater than 500 Ω or distortion will result, particularly at higher frequencies. The maximum frequency for the sine and square waveforms is 1 MHz, while that for the triangle and ramps is 11 kHz.

AMPLitude

AMPLitude is an optional command which follows the type of source definition VOLTage, POWer or CURRent.

The full command is [SOURce:] followed by the voltage, power or current sub command. The optional commands [:LEVel] and/or [:IMMediate], and then :AMPL followed by a numeric value and an OFFSet value.

The amplitude range for each waveform is given in Table 4-2. The ranges given are only applicable when no DC offset has been set. When this is the case, see Table 4-4.

Table 4-2. Amplitude Limits of AC Functions

	Peak-to-Peak		RMS		dBm (50Ω)	
Function	min.	max.	min.	max.	min.	max.
SINE WAVE	1 mV	10 V	0.354 μV	3.536 V	−56.02	+23.98
SQUARE WAVE	1 mV	10 V	0.500 μV	5.000 V	−53.01	+26.99
TRIangle	1 mV	10 V	0.289 μV	2.888 V	−57.78	+22.22
RUP (Pos. slope ramp)	1 mV	10 V	0.289 μV	2.888 V	−57.78	+22.22
RDOWn (Neg. slope ramp)	1 mV	10 V	0.289 μV	2.888 V	−57.78	+22.22

Note

At output amplitudes of <50 mV in extreme environmental conditions, it is recommended you use a double shielded BNC cable. For example, use HP p/n 5180-2459 (1.22 m, RG58V Triax, 50Ω).

High-Voltage Option (Output Amplifier :OUTPut:AMPLify)

When the high-voltage output is used (option 001 is installed), a maximum output of 40 V peak-to-peak is available into a high impedance. The load resistance must be more than 500Ω or distortion will result, particularly at higher frequencies. To ensure square wave overshoot of <5% of the peak-to-peak output, the total capacitance connected to the output should be <500 pF. An error will occur if the amplitude is given in dBm for the high-voltage option.

The amplitude limits for the high-voltage option are shown in Table 4-3. The ranges given, are only applicable when no DC offset has been specified. When this is the case, see Table 4-4.

Note

When the high-voltage option is switched on, the output amplitude/offset "jumps" to its 4-fold value. When it is switched off, it is automatically decreased by a factor of four.
For example, the amplitude=1 V(p-p). Turning the high-voltage on causes the amplitude output to be 4 V(p-p). Turning the high-voltage off causes the amplitude output to be 1 V(p-p) again.

Table 4-3. High-Voltage Output Amplitudes

	Peak-to-Peak		RMS	
Function	**min.**	**max.**	**min.**	**max.**
SINe wave	4 mV	40 V	1.42 mV	14.14 V
SQUare wave	4 mV	40 V	2.00 mV	20.00 V
TRIangle	4 mV	40 V	1.16 mV	11.55 V
RUP (Pos. slope ramp)	4 mV	40 V	1.16 mV	11.55 V
RDOWn (Neg. slope ramp)	4 mV	40 V	1.16 mV	11.55 V

OFFSet

The command is [:AMPL]:OFFSet followed by a numerical value representing the required DC offset.

The DC offset range is dependent upon amplitude and the high-voltage option (if installed). See Table 4-4 for a list of the DC offsets allowed.

If a DC offset is specified that is too large for the amplitude already programmed, or if the AC amplitude is increased beyond the level where the amplitude and offset are compatible, the **Error** lamp will illuminate on the front panel and the entry value is not accepted.

Offset Only, No AC Function

When the DC function is activated, then no AC function is activated. The DC voltage output may then be programmed from 0 mV to ±5 V, with 4 digit resolution.

AC with DC Offset

When DC offset is added to any AC function, there are minimum and maximum offset limits which must be observed. These limits are affected by the AC voltage and internal attenuator settings listed in Table 4-4. Resolution of a DC offset entry (with AC function) is determined by the resolution of the AC amplitude. The following equation may be used to determine maximum offset voltage:

Maximum DC offset = (5/A) - (Amptd/2)

where A = Attenuation factor (from Table 4-4) and
Amptd = Amplitude in V(p-p) of the AC function.

Table 4-4. Maximum DC Offset with any AC Function

AC Amplitude Entry (peak-to-peak)		Maximum DC Offset (+ or −)	Minimum DC Offset Entry	Range	Attenuation Factor
1.000 mV to 3.333 mV	with with	4.500 mV 3.333 mV	0.001 mV	7	A = 1000
3.334 mV to 9.999 mV	with with	14.99 mV 11.66 mV	0.001 mV	6	A = 300
10.00 mV to 33.33 mV	with with	45.00 mV 33.33 mV	0.010 mV	5	A = 100
33.34 mV to 99.99 mV	with with	149.9 mV 116.6 mV	0.010 mV	4	A = 30
100.0 mV to 333.3 mV	with with	450.0 mV 333.3 mV	0.100 mV	3	A = 10
333.4 mV to 999.9 mV	with with	1.499 V 1.166 V	0.100 mV	2	A = 3
1.000 V to 9.998 mV	with with	4.500 V 0.001 V	1.000 mV	1	A = 1

High-Voltage Option

When the high-voltage output is used (option 001 is installed), the minimum and maximum permissible DC offset voltages may be determined by multiplying the amplitude and offset values in Table 4-4 by four. The equation given on the previous page must be changed to:

Maximum DC offset = (20/A) - (Amptd/2)

where A = Attenuation factor (from Table 4-4) and
Amptd = Amplitude in V(p-p) of the AC function.

Resolution of a DC offset entry is determined by the resolution of the AC amplitude.

PHASe

The command is :PHASe followed by a decimal value representing the amount (in degrees of angle) of phase shift required between the output signal, and an external reference signal.

Another synthesized function generator (for example, another HP E1440A or an HP 3324A, can be synchronized with the HP E1440A (or vice versa). Either a reference frequency signal from the other instrument is connected to the external frequency reference input of the HP E1440A , or the signal from the output of the HP E1440A is connected to the other instrument. Changing the phase of the HP E1440A will then cause the phase between the two instruments to change accordingly.

Note In this case the phase relationships of the two instruments are not calibrated, just locked.

For square wave frequencies below 25 kHz, phase changes greater than 25° may result in a phase shift of ±180° from the desired amount.

The phase limit is ±720.0°, with a resolution of 0.1°.

After entering a phase shift, the new phase may be assigned the zero-phase position; subsequent changes in phase are made with reference to this value.

Value Coupling

General

Value coupled commands are managed by means of command groups as illustrated in Table 4-5 and Figure 4-3.

Table 4-5. E1440 Command Group Assignment

Command	Command group
:ABOR	0
:INIT	0
:INIT:CONT	0
:VOLT	3
:VOLT:OFFS	3
:VOLT:UNIT	0
:FREQ	1
:FREQ:MODE	0
:FREQ:STAR	2 (*)
:FREQ:STOP	2 (*)
:FREQ:SPAN	2 (*)
:FREQ:CENT	2 (*)
:FREQ:SPAN:HOLD	0 (*)
:FREQ:SPAN:LINK	0 (*)
:FREQ:SPAN:FULL	0 (*)
:MARK<n>	0 (*)
:MARK<n>:FREQ	0 (*)
:MARK<n>:AOFF	0 (*)
:SWE:TIME	0 (*)
:SWE:TIME:RETR	0 (***)
:SWE:TIME:RETR:AUTO	0 (***)
:SWE:DIR	0 (*)
:LIST:FREQ:STAR	0 (**)
:LIST:FREQ:STOP	0 (**)
:LIST:FREQ:MARK	0 (**)
:LIST:FREQ:MARK:STAT	0 (**)
:LIST:FREQ:SPAC	0 (**)
:LIST:DWEL	0 (**)
:LIST:SEQ	0 (**)
:ROSC:SOUR	0
:ROSC:AUTO	0
:FUNC	1
:AM:STAT	0
:PM:STAT	0
:OUTP	0
:OUTP:AMPL	0
:OUTP:TTLT<n>	0
:OUTP:TTLT<n>:SOUR	0
:OUTP:TTLT<n>:AOFF	0
:PHASe	0
:PHAS:STEP	0
:PHAS:UNIT	0
:PHAS:REF	0

Note

(*) Param. evaluation deferred until "FREQ:MODE SWE" is set.
(**) Param. evaluation deferred until "FREQ:MODE LIST" is set.
(***) Param. evaluation deferred until "FREQ:MODE SWE" or "FREQ:MOD LIST" is set.

All commands that have the same command group (except 0) are coupled. The following commands are un coupled:

- All commands in group 0
- All queries
- All common commands
- The pseudo command 'program message terminator' <CR/LF>

The algorithm used to manage value coupled commands is described in pseudo code, see Listing below for the pseudo code and for an example. The following pseudo variables and functions are used in the description :

Variable	Description
LAST_GROUP	is the group-id of the most recent received command, it is set to 0 after power on.
THIS_GROUP	is the group id of the current command.
CLEAN_UP()	is a routine that executes pending commands.
STORE()	is a routine that 'stores' pending commands.
EXEC()	is a routine that executes the current command.

Example

```
if ( LAST_GROUP == 0 )
  {
  if ( THIS_GROUP == 0 )
    {
    EXEC() ;
    }
  else
    {
    STORE() ;
    LAST_GROUP = THIS_GROUP ;
    }
  }
else
  { /* LAST_GROUP != 0, commands are pending */
  if ( THIS_GROUP != LAST_GROUP )
    {
    CLEAN_UP() ;
    if ( THIS_GROUP == 0 )
      {
      EXEC() ;
```

```
      }
    else
      {
      STORE() ;
      }
    LAST_GROUP = THIS_GROUP ;
    }
  else
    { /* THIS_GROUP == LAST_GROUP & LAST_GROUP != 0 */
    STORE() ;
    }
}
```

Figure 4-3. Handling of Value Coupled Commands

For ease of understanding, exception handling is not shown in the pseudo code.

In words : An execution error in EXEC() discards the current command and sets LAST_GROUP to 0.

An execution error in CLEAN_UP() discards all pending commands and sets LAST_GROUP to 0.

A parser error forces execution of all pending commands and sets LAST_GROUP to 0.

Example of processing value coupled commands

Assume a program message composed of commands with the following group assignments (suffix) :

A0; B1; C1; D0; E2; F2; G3; H3 <CR/LF>

Such a program message would be processed in the following manner:

A : THIS_GROUP=0, LAST_GROUP (assumed)=0, A is executed.
B : THIS_GROUP != 0, LAST_GROUP == 0, B is made pending.
C : THIS_GROUP == LAST_GROUP != 0, C is made pending.
D : THIS_GROUP == 0 != LAST_GROUP, B and C are executed, D is executed.
E : THIS_GROUP != 0, LAST_GROUP == 0, E is made pending.
F : THIS_GROUP == LAST_GROUP != 0, F is made pending.
G : THIS_GROUP != 0 != LAST_GROUP, E and F are executed, G is made pending.
H : THIS_GROUP == LAST_GROUP != 0, H is made pending.
<CR/LF> : all pending commands (G and H) are executed.

Sweep

For the sweep systems, a second level of evaluation delay is implemented. Sweep parameter conflicts (with 'outer' parameters, e.g. FUNCtion) are not evaluated (no error is generated) as long as they are not 'active'.

Sweep parameters are active when they are used in a sweep and when the FREQuency:MODE is set to SWEep or LIST. In other words, a sweep parameter error (e.g. stopfreq. too high for function) is not generated until the interval containing the parameter is selected for sequencing and FREQ:MODE is set away from CW/FIXed.

This implementation allows a programmer to change the output function temporarily, without having to re-program dozens of parameters, if he does not want to sweep this function.

Example :

Assume a user has set up 50 intervals, all sweeping in the range of 10 to 21 MHz, and he wants to switch the waveform to triangle temporarily. In a strict approach this is not allowed unless he reprograms all 50 intervals, because the maximum frequency for output function triangle is 11 kHz.

Functional Coupling

[:SOURce]:FREQuency [:CW]

Setting the frequency through its CW node switches FREQ:MODE to CW.

[:SOURce]:ROSCillator :SOURce

Setting the reference oscillator source switches [SOURce]:ROSCillator:AUTO to OFF.

[:SOURce]:SWEep :TIME:RETRace

Setting the sweep retrace time switches [SOURce]:SWEep:TIME:RETRace:AUTO to OFF.

Programming Pitfalls

Certain combinations of commands and changes of values, can cause conflict within the instrument. Sometimes, this is merely because the instrument refers to a stored value that is no longer compatible. The known pitfalls detailed in this section should be of help.

Sweep

When the instrument is controlled by the sweep or list subsystem several commands/queries are not allowed. Table 4-6 shows all commands and whether they (or their query) is allowed/has a special effect when issued while the instrument is in FREQ:MODE SWEEP or in FREQ:MODE LIST. The commands are given in their short form with optional command nodes deleted; trailing ellipses (" ... ") on a command, indicate that the table entry is valid for all sub commands that might follow the command. Command aliases (e.g. VOLT | POW | CURR) are not shown.

Table 4-6.
Illegal E1440 Commands in FREQ:MODE LIST / SWEEP

Command	Mode sweep		Mode List	
	cmd	query	cmd	query
:ABOR	—	NAP	—	NAP
:INIT	(1)	NAP	(1)	NAP
:INIT:CONT	—	—	—	—
:VOLT	—	—	—	—
:VOLT:OFFS	—	—	—	—
:VOLT:UNIT	—	—	—	—
:FREQ	(2)	ILL	(2)	ILL
:FREQ:MODE	—	—	—	—
:FREQ:STAR	ILL	—	—	—
:FREQ:STOP	ILL	—	—	—
:FREQ:CENT	ILL	—	—	—
:FREQ:SPAN	ILL	—	—	—
:FREQ:SPAN:	—	—	—	—
:FREQ:SPAN:	—	—	—	—
:FREQ:SPAN:	ILL	NAP	—	NAP
:MARK<n>	ILL	—	—	—
:MARK<n>:FREQ	ILL	—	—	—
:MARK<n>:AOFF	ILL	NAP	—	NAP
:SWE:TIME	ILL	—	ILL	—
:SWE:TIME:RETR	ILL	—	ILL	—
:SWE:TIME:RETR:AUTO	ILL	—	ILL	—
:SWE:DIR	ILL	—	ILL	—
:LIST: ...	—	—	ILL	—
:ROSC: ...	—	—	—	—
:FUNC	ILL	—	ILL	—

Table 4-6.
Illegal E1440 Commands in FREQ:MODE LIST / SWEEP (continued)

Command	Mode sweep		Mode List	
	cmd	query	cmd	query
:AM:STAT	—	—	—	—
:PM:STAT	—	—	—	—
:OUTP	—	—	—	—
:OUTP:AMPL	ILL	—	ILL	—
:OUTP:TTLT<	ILL	—	ILL	—
:OUTP:TTLT<	ILL	—	ILL	—
:OUTP:TTLT<	—	NAP	—	NAP
:PHASe	ILL	—	ILL	—
:PHAS:STEP	—	—	—	—
:PHAS:REF	—	NAP	—	NAP
:PHAS:UNIT	—	—	—	—
:CAL	NAP	ILL	NAP	ILL
:STAT: ...	—	—	—	—
:SYST: ...	—	—	—	—
*CLS	—	NAP	—	NAP
*ESE	—	—	—	—
*ESR	—	—	—	—
*SRE	—	—	—	—
*STB	NAP	—	NAP	—
*IDN	NAP	—	NAP	—
*WAI	—	NAP	—	NAP
*OPC	—	—	—	—
*RST	—	NAP	—	NAP
*SAV	ILL	NAP	ILL	NAP
*RCL	—	NAP	—	NAP
*TST	NAP	ILL	NAP	ILL
*OPT	NAP	—	NAP	—

The symbols in the table have the following meaning :

(1) INIT is legal IN MODE sweep/list ONLY. An error is generated if it is received while in mode CW | FIX, or while a sweep is already running.

(2) If a frequency is entered while in mode sweep/list then the frequency mod is switched to CW.

NAP Not APplicable, that means that either the query only, or the non-query form of a command exists.

ILL ILLegal, the command/query is not allowed. In the case of a query, a fake value of 0.0 is returned but an error is generated.

— No restriction.

Minimal MARKer distances

When setting up a sweep with markers in it, or a list sweep with intervals with markers in it, a minimum distance must be observed between START -▸ MARKER, MARKER -▸ MARKER and MARKER -▸ STOP. Unfortunately this minimum distance is not a fixed frequency distance, but a fixed TIME distance of 1.5 msec.

The minimal frequency distance is determined by the sweep frequency span (ABS(STOP-START)) and the sweep (dwell) time.

The equation is :

$$\frac{min\_dist[Hz] = (sweep\_span[Hz] * 1.5E^{-3})}{sweep_time[sec]}$$

Example :

:FREQ:START 1 kHz ;
:FREQ:STOP 3 kHz ;
:SWE:TIME 2

$$\frac{min\_dist[Hz] = (2000[Hz] * 1.5E^{-3})}{2[sec]}$$

$$min\_dist[Hz] = 1.5$$

The pitfall here is that one can turn a legal marker into an illegal marker, by touching nothing except the sweep (dwell) time.

Example 2 : (identical but sweep time is significantly shorter)

:FREQ:START 1 kHz ;
:FREQ:STOP 3 kHz ;
:SWE:TIME 0.1

$$\frac{min\_dist[Hz] = (2000[Hz] * 1.5E^{-3})}{0.1[sec]}$$

$$min\_dist[Hz] = 30.0!$$

FUNC TTL and FUNC DC limitations

For the output FUNCtions TTL and DC, some instrument parameters are fixed. The commands affected for FUNCtion TTL are VOLT and VOLT:OFFS, the commands affected for FUNCtion DC are FREQ and VOLT.

If FUNCtion is TTL :

:VOLT <value>	—> error
:VOLT?	—> error, fixed return is 2.4 (typical TTL level)
:VOLT:OFFS <value>	—> error
:VOLT:OFFS?	—> error, fixed return is 0.0

If FUNCtion is DC :

:FREQ <value>	—> error
:FREQ?	—> error, fixed return is 0.0
:VOLT <value>	—> error
:VOLT?	—> error, fixed return is 0.0

:VOLT <value> <unit> / :VOLT:UNIT

The E1440 accepts three different 'base units' in the VOLT command.

V (Volts peak - peak)
VRMS (Volts root mean square)
dBm (dB ref. to 1 mW on 50Ω - 0 dBm—▸ 1 mW on 50Ω)

There are two ways to tell the instrument which unit to use:
set the default unit via :VOLT:UNIT command. (e.g. ':VOLT:UNIT dBm;')
append the unit string to the parameter in the :VOLT command. (e.g. ':VOLT 1.3 dBm;')

A unit appended to the :VOLT command has higher priority than the default unit, however the default unit is NOT changed by the :VOLT command.

To keep track of all this, the instrument deals internally with two units. One is the default unit (entered via ':VOLT:UNIT'), the other is the so-called effective unit (entered implicitly via ':VOLT'). The effective unit is not queryable by the user but has a much higher impact on the instrument operation than the default unit.

The default unit is used in only two situations :

When a VOLT command has no unit then effective = default.

All query responses are given in the default unit.

The effective unit is used when :

- the volt value is checked against bounds. (observe that the transformation rules from dBm or VRM to V are different for different output functions. The hardware limits are V - limits!)
- an attempt is made to switch the output amplifier on, this is not possible when the real unit is dBm! (the dBm value is only correct for a 50Ω load, and the output amplifier cannot drive a 50Ω load.)
- the output function is changed. The instrument always keeps the output voltage in the effective unit: that means that the volt peak-peak value for example, measured on the output connector, changes when the FUNCtion is changed from SIN to SQU and the effective unit is not V.

This implementation - although straightforward - might lead to little confusion when not understood. It is quite usual for the following odd-looking thing to happen :

Error 'No dBm allowed when output amplifier is active' on command ':AMPL ON' and response for ':VOLT:UNIT?' is 'V'.

REASON : effective unit is dBm.

*WAI and *OPC?

Both commands cause the command parser to stop parsing further commands until a currently running sweep terminates. If one uses these commands without care, the instrument might enter a state where it appears to have 'hung up'.

There are two things to consider:

- First, sweeps can be incredibly long. Especially in LIST sweep, one might sequence up to 100 intervals and each interval might have a dwell time of up to 100000 seconds. This means a 'full blown' LIST sweep might last for up to $10E^6$ seconds (about 116 days!).
- Second, a continuous sweep (INIT:CONT ON) NEVER stops!

To bring a HP E1440 back to life, that has been blocked by a command such as:

'FREQ:MODE SWE;:INIT:CONT ON;*WAI.... <more commands>'

('<more commands>' might be whatever You want - it does not matter because it will never be seen by the parser)

issue a <Device Clear> or <Selected Device Clear> command to the instrument. Using HP Rocky Mountain BASIC this can be done as follows:

```
1000 ! E1440 is at VXIbus address 70911
1010 ! (Select code of controllers VXIbus interface card : 7 )
1020 ! (Primary VXIbus address of Slot 0 commander : 09 )
1030 ! (E1440 logical address = 88 right shifted 3 bits : 11 )
1040 !
1050 CLEAR 7    ! All instruments connected to this
1060            ! VXIbus receives a DCL.
1070 !
1080 CLEAR 70911    ! E1440 alone is cleared.
```

Connections

Connection to other VXI mainframe modules or external test equipment, is achieved through the front panel BNC connectors in a conventional way.

5

Command Reference

Using This Chapter

This chapter describes the Standard Commands for Programmable Instruments (SCPI) commands and indicates the IEEE 488.2 common (*) commands that are applicable to the HP E1440A Synthesizer. The chapter contains the following main sections:

Command Types

Commands are separated into two types: IEEE 488.2 Common Commands and SCPI Commands.

SCPI Command Format

The SCPI commands perform functions for making measurements and setting output levels, or data retrieval. A command subsystem structure is hierarchical, usually consisting of a top (root) level command, with one or more low level commands and their parameters. The following example shows a typical subsystem:

```
:SOURce
  :VOLTage
    :LEVel
    :UNIT
  :POWer
```

SOURce is the root command, VOLTage, POWer are secondary level commands and LEVel, UNIT are third level commands. The precise syntax for these commands and others, is given later in this chapter.

Command Separator

A colon (:) always separates one command from the next lower level command as shown below:

:SOURce:VOLTage:LEVel <CR/LF> (return)

The SCPI command parser

The HP E1440A firmware contains a piece of software, called the SCPI command parser, which is responsible for decoding the program strings entering the instrument. For efficient programming of the instrument, it is helpful to understand how this parser operates.

Definition of terms

Before explaining the parser operation, we should explain some of the terms used in the text.

Common commands / SCPI commands

There are two command types understood by the E1440, common commands and SCPI commands.

- Common commands all begin with an asterisk ('*'). They are organized in a non-hierarchical ('flat') manner.
- A common command is allowed where a program message unit (see below) is allowed.
- Common commands do not affect the current base node (see below).
- SCPI commands are all those commands that do not begin with an asterisk. They are organized hierarchically.

Program message

A program message consists of one or more program message units (see below) separated by program message unit separators (semicolon (';') and terminated by a program message terminator (carriage return - line feed (abbreviated as <CR/LF>) sequence).

An example for a program message is :
':VOLT:OFFS 1 V ; :FREQ 5 kHz <CR/LF>'

Note

As you see, the final ';' (which should be between ' ... kHz' and '<CR/LF') can be omitted.

This program message actually consists of two program message units:

':VOLT:OFFS 1 V' and ':FREQ 5 kHz'

Program message unit (command)

A program message unit is what we commonly call a command. The term 'command' is used below, because it sounds more familiar and is not as typing-intensive as 'program message unit'.

A command consists of one or more command nodes (see below) separated by colons (':'). The first command node might be prepended by a colon as well, but that has a special effect. If a command has a parameter, then the parameter must be separated by at least one space character (no tab) from the end node (see below). If the command is a query, then a question mark ('?') must immediately follow the end node without a space.

An example for a command is : ':VOLT:OFFS 1 V'

This command consist of two command nodes : 'VOLT' and 'OFFS'

Command node

Command nodes are the short mnemonic words that are chained together to form commands. Nodes can usually be given in a short form or in a long form; the two forms are indicated by upper/lower case typing in the language reference.

The entry 'FREQuency' in the language reference, for instance, means that either 'FREQ' or 'FREQUENCY' might be used but nothing else, for instance 'FREQU' is not allowed.

Notice that case in the language reference, is for clarification only - the parser is NOT case sensitive, 'freq', 'FREQ' or 'FrEq' are all the same.

Optional node

An optional node is a node that, as the name implies, can be supplied or not. Optional nodes are shown within square brackets in the language reference.

Given the following command definition : ('VOLTage', 'POWer' and 'CURRent' are synonyms; they have exactly the same meaning.)

```
[:SOURce]
  :VOLTage | POWer | CURRent
    [:LEVel]
      [:IMMediate]
        [:AMPLitude] <numeric value>
        :OFFSet <numeric value>
  :UNIT V | DBM | VRMS
```

the following commands are all equivalent :

':SOUR:VOLT:LEV:IMM:AMPL.....'
':VOLT:LEV:IMM:AMPL.....'
':VOLT.....'
':VOLT:AMPL.....'

Although they are equivalent in their effect on the instrument hardware, they are not equivalent for the parser (see current base node).

End node

The end node is simply the last command node in a command STRING.

Example :
':VOLT.....' end node is 'VOLT'.
':VOLT:AMPL.....' end node is 'AMPL'.

Implied root node

The implied root node is a theoretical, unnamed and not really existent command node, that prepends all root-level command nodes of a given SCPI language.

Example : the partial command ref.

:INITiate

    [:IMMediate] <event>
      :CONTinuous <boolean>
    :ABORt <event>

can be equated to:

<root>:INITiate

    [:IMMediate] <event>
      :CONTinuous <boolean>

<root>:ABORt <event>

Remember

The <root> node does not really exist. Do not try programming strings such as ":ROOT:INIT"

Current base node

The current base node is a virtual node like the <root> node. It is a role that many nodes can play temporarily during the process of parsing.

The current base node is not in the language definition, it is in the parser. It is the node from where the parser starts when it tries to match an incoming command string against the language definition.

How the parser works

In this section we deal with the parsing of program messages and program message units (commands) only.

Parameters (numbers, suffixes, enumerated values) have to be parsed too of course, but this is quite straightforward and is not discussed here.

The base operation of the parser is quite simple :

Accept input characters until a node is gathered (until ':')

check the gathered node is below the current base node, skip optional nodes if necessary.

IF node is ok AND node is potential end node, AND blank (' ') follows AND command takes parameter, THEN parse parameter.

IF node is ok AND node is potential end node AND question mark ('?') follows AND command has query form, THEN do query.

IF node is ok AND node is not end node AND colon (':') follows THEN gather next node.... ...

ELSE generate syntax error.

A complication is introduced by the current base node. However the rules that determine which node is the current base node, are very simple:

- After reset, any syntax error, receipt of a program message terminator (<CR/LF>) and if a command starts with a colon(':') the root node is the current base node.
- After successful parsing (and execution) of a command, the node in front of the end node of the command string, becomes the current base node for the next program message unit. If the command consisted of only one node then the current base node is untouched.

Example

In case this might sound a little complex, an example should help.

Assume the following language definition :

<root>

```
  :ABORt  <event>
  [:SOURce]
     :VOLTage | POWer | CURRent
        [:LEVel]
           [:IMMediate]
              [:AMPLitude]  <numeric value>
              :OFFSet  <numeric value>
        :UNIT  V | DBM | VRMS
```

Again, keep in mind that the <root> node does not exist in reality.

Assume further that after power on, <root> is the current base node.

Now the following programming string is sent to the instrument :

':VOLT:UNIT DBM;LEV 1;OFFS 0.5;:ABOR<CR/LF>'

Inside the parser :

- ':VOLT:UNIT' is found under current base node <root> (the optional node 'SOURce' has been skipped), the parameter ('DBM') is parsed and the command is executed without error. ▸ ':VOLT' is the new current base node.
- 'LEV' is found under the current base node ':VOLT', the optional nodes 'IMM' and 'AMPL' are skipped, the parameter '1' is parsed

and the command is executed without error.
The command 'LEV' has only one node, therefore the current base node is not changed.

- 'OFFS' is found under the current base node ':VOLT' (the optional nodes 'LEV' and 'IMM' have been skipped), the parameter '0.5' is parsed and the command is executed without error.
The command 'OFFS' has only one node, therefore the current base node is not changed.
- The colon (':') prepending 'ABOR' is seen. ▶ <root> is the new current base node.
- 'ABOR' is found under the current base node <root>, the command takes no arguments and executes without error.
The command 'ABOR' has only one node, therefore the current base node is not changed.
- The program message terminator ('<CR/LF>') is seen. ▶ <root> is the new current base node.

One final note:

The term 'command executes' means that the command is executed from the point of view of the parser. If You look at it as an instrument user, you should refer to the section "Value coupling" in chapter 4 for more information about command execution.

Parameters

Parameter types. The following table contains explanations and examples of parameter types which might be encountered later on in this chapter.

Parameter Type	Explanations and Examples
Numeric	Accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. 123, $123E^2$, -123, $-1.23E^2$, 0.123, $1.23E^{-2}$, $1.23000E^{-01}$. Special cases include MIN, and MAX.
Boolean	Represents a single binary condition that is either true or false, parameters are ON/OFF or 1/0 (1 and ON are synonymous).
Event	Identifies a command which has no parameter.
Discrete	Selects from a finite number of values. These parameters use mnemonics to represent each valid setting. An example is [:SOURce]:FUNCtion *<output function>* command, where *output function* could be "TRI" or "SIN".

Optional Command Nodes: Parameters shown between square ([ ]) brackets are optional parameters (The brackets are not part of the command and are not sent to the instrument.) If you do not specify a value for an optional parameter, then the instrument chooses a default value. For example, consider the [:SOURce]:FUNCtion[:SHAPe] command accompanied by the TRIangle parameter. This would be sent to specify a saw tooth output waveform. The command could be sent as :SOUR:FUNC TRI, or :FUNC:SHAP TRI, or :FUNC TRI. Each form is correct. Be sure to place a space between the command and it's parameter.

Linking Commands

Linking IEEE 488.2 Common Commands with SCPI Commands. Use a semicolon between commands. For example:
*RST;:OUTPut:TTLTrg3 ON

Linking Multiple SCPI Commands. Use both a semicolon and a colon between commands. For example:
:SOURce:VOLTage:UNIT V;:VOLTage:AMPLitude 2.5

Common Command Format

The IEEE 488.2 standard defines the Common commands that perform universal functions such as reset, self-test, status byte query etc. Common commands are always four or five characters in length, always begin with the asterisk (*) character, and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of Common commands are:
*RST, *STB?, *ESR

SCPI Command Reference

This section describes the Standard Commands for Programmable Instruments (SCPI commands) that may be used for the HP E1440A. Commands are listed alphabetically by subsystem and also within each subsystem.

ABORt

The ABORt command subsystem removes the synthesizer from the INITiate state and places it in an idle state.

Subsystem Syntax

:ABORt <event>

Comments

- **Related commands:** :INITiate:CONTinuous, :INITiate[:IMMediate]
- ***RST Condition:** After a reset, the synthesizer acts as though an :ABORt has occurred
- :ABORt cancels any impending commands

Example

Stopping a Sweep with :ABORt

	Program	Result
10	`OUTPUT 70911; ":INIT:CONT ON"`	Select continuous sweep and initialize
20	`OUTPUT 70911; ":FREQ:MODE SWE"`	Sets in sweep made and starts immediately
30	`OUTPUT 70911; ":ABOR"`	Sweep stops and resets, then restarts immediately

or:

10	`OUTPUT 70911; ":INIT:CONT OFF"`	Select single sweep
20	`OUTPUT 70911; ":FREQ:MODE SWE"`	Sets to sweep mode (sweep is in reset state)
30	`OUTPUT 70911; ":INIT"`	Sweep starts
40	`OUTPUT 70911; ":ABOR"`	Sweep stops and is set to reset state, (asynchronous)

CALibration

The CALibrate subsystem performs a system calibration. In the HP E1440A , only one implementation (:ALL?) is supported, which allows the command module to calibrate and check the synthesizer.

Subsystem Syntax

:CALibration[:ALL]? (Query only)

Comments

- **Related commands:** [:ALL]
- :CAL? Performs a full calibration of the synthesizer. The query response is a zero if calibration is successful, and a non-zero number (error code), accompanied by an error message, if calibration is unsuccessful.

CAL? Results

Possible responses to the :CAL? command are listed below. The ':CAL?' response is a single number that is to be interpreted as enumeration.

For the user the actual value of the calibration result is of minor interest, the main distinction here is 'zero or non-zero'. However, the actual value should be reported to the service people.

Code	Meaning
0	No error detected during calibration.
1	Level comparator is defect. Hardware stated out that compare level is, at the same time, above signal high peak and below signal low peak.
2	Level never below low signal. It is not possible to set the compare level lower than the signal low peak.
3	Level never above low signal. It is not possible to set the compare level higher than the signal low peak.
4	Level never above high signal. It is not possible to set the compare level higher than the signal high peak.
5	Level never below high signal. It is not possible to set the compare level lower than the signal high peak.
6	Calibration offset and/or gain value is out of range. The correction factors for the amplitude / amplitude offset correction that were found during the calibration are out of range. That means that with these values it is not possible to reach the maximum output voltages without exceeding the capabilities of the internal analog signal circuitry.
7	AC ripple on DC signal is too high. For output function DC only—the AC ripple of the DC output signal is out of specified limits.

CALibration

8	Self test was called while instrument was in :FREQ:MODE SWEEP or LIST. This is a meta-error message, the calibration did not fail—it is just illegal to call it in :FREQ:MODE SWEEP/LIST. Note that no calibration has been done!

INITiate

The :INITiate command subsystem controls the initiation of the sweep generator for one cycle. INITiate enables the module whilst ABORt disables it.

Subsystem Syntax

:INITiate

:CONTinuous <boolean>
[:IMMediate] <event>

:CONTinuous

:INITiate:CONTinuous ON|Off|1|0 enables or disables continuous sweep or waveform output from the HP E1440A .

Parameters

Parameter Name	Parameter Type	Range of Values
ON|OFF|1|0	boolean	ON|OFF|1|0

Comments

- **Continuous Sweep Operation:** Continuous sweep is enabled with the :INIT:CONT ON or :INIT:CONT 1 command.
- **Non Continuous Operation:** Non Continuous operation of the HP E1440A is enabled with the :INIT:CONT OFF or :INIT:CONT 0 command.
- **Stopping Continuous Sweep:** Send the ":INIT:CONT OFF;:ABORt" command.
- **Related Commands:**

[:IMMediate]

The :INITiate:IMMediate command causes the module to start a sweep immediately.

Comments

- If the instrument is not in an idle state, then this command has no effect and an error code is generated
- :INIT[:IMM] is an event and therefore has no *RST state. A *RST command will however set the instrument to idle.
- If :INIT:CONT OFF is selected, when :INIT[:IMM] is commanded, the system is enabled for one cycle only. The instrument then reverts to idle awaiting another :INIT[:IMM] command.
- If :INIT:CONT ON is selected, the instrument starts sweeping as soon as it enters :FREQ:MODE, SWEep or LIST

OUTPut

The :OUTPut command subsystem controls how the HP E1440A output signal is made available. In it's simplest form the command :OUTPut ON (or 1), or :OUTPut OFF (or 0), switches the HP E1440A output signal at the front panel BNC connector.

Subsystem Syntax

```
:OUTPut
  :[STATe] <boolean>
  :AMPLify
    [:STATe] <boolean>
  :TTLTrg<n>
    [:STATe] <boolean>
    :SOURce SYNC|MARKer
    :AOFF <event>
```

[:STATe]

:OUTPut [:STATe] ON|OFF|1|0 enables or disables the HP E1440A output signal at the front panel BNC connector.

Parameters

Parameter Name	Parameter Type	Range of Values
ON|OFF|1|0	boolean	ON|OFF|1|0

Comments

- **Front Panel Output:** Is available with the :OUTP ON or :OUTP 1 command.
- **Front Panel Output:** Is removed from the front panel output BNC connector with the :OUTP OFF or :OUTP 0 command
- **Related Commands:** :AMPLify[:STATe], :TTLTrg<n>:SOURce:MARKer, :TTLTrg<n>:AOFF
- ***RST Condition:** OUTPut[:STATe] OFF (no output available)

Note

The SYNC output is not affected by the OUTPut command, it is always active

[:STATe]?

OUTP[:STAT]? queries the HP E1440A to discover whether an output is meant to be available at the front panel connector.

:AMPLify

High Voltage Option 001

The :OUTP:AMPL[:STAT] command takes a boolean argument and switches the Option 001 high-voltage amplifier into the output signal path. This amplifier has a fixed amplification factor of 4.

Parameters

Parameter Name	Parameter Type	Range of Values
ON|OFF|1|0	boolean	ON|OFF|1|0

Comments

- The high-voltage amplifier is specified for a load of 500 Ω, the normal output impedance is 50 Ω.
- The HP E1440A treats the high-voltage amplifier as an external accessory. This means that the programmed output voltage is not changed when the high-voltage amplifier is switched ON or OFF, but the output level will increase or decrease by a factor of four.
- When queried, the HP E1440A responds with the true output voltage, provided the impedance of the connected device matches that of the module.
- The high-voltage amplifier is an installable option, if it is not installed, an error is generated. See *OPT? in *Common Commands* section later in this chapter.
- The high-voltage amplifier has a maximum frequency of 1MHz. It cannot be switched on if :FREQ > 1MHz. Whilst it is ON, :FREQ is limited to ≤1MHz.

:TTLTrg<n>[:STATe]

This command controls the TTL <n> trigger line driver output. The suffix <n> is in the range 0 to 7.

Parameters

<table>
<tr><th>Parameter Name</th><th>Parameter Type</th><th>Range of Values</th></tr>
<tr><td>ON|OFF|1|0</td><td>boolean</td><td>ON|OFF|1|0</td></tr>
</table>

Comments

- **:TTLTrg ON/1:** The TTL line is driven by the HP E1440A
- **:TTLTrg OFF/0:** The TTL line driver is in a high impedance state and the line is available to be used by another test instrument
- Every TTL trigger line is associated with one of two possible sources (see next sub-command).
- The HP E1440A limits the number of "ON" TTL lines to one per source.

:TTLTrg<n>:SOURce

This command selects the source for the TTL trigger line <n> driver output. The suffix <n> is in the range 0 to 7.

Parameters

Parameter	Description
SYNC	If the specified TTL line driver is enabled, the TTL output is driven by the SYNC signal. Only one driver linked to SYNC may be enabled at a time.
MARKer	If the specified TTL line driver is enabled, the line is driven by the sweep/list marker signal. Only one driver linked to MARKer may be enabled at a time.

Note

1. It is permissible to have one SYNC and one MARKer signal set to ON at the same time. But two or more SYNC/MARK lines set to ON at the same time is not allowed.
2. The VXI back plane limits the TTL-trigger signal to a frequency of $\leq$10MHz. If one TTLTrig is ON and has SOURce SYNC, then the maximum frequency of the instrument is 10MHz. If current FREQ is >10MHz, then no SYNC trigger can be switched ON.

:TTLTrg<n>:AOFF

This command switches OFF all TTL trigger lines.

[:SOURce]

This command is the main command for the HP E1440A and it has many subsets described below. The command is an implied command followed by a parameter specifying the type of signal source.

Subsystem Syntax

```
[:SOURce]
  :VOLTage | :POWer | :CURRent
    [:LEVel]
      [:IMMediate]
        [:AMPLitude]  <numeric value>
        :OFFSet  <numeric value>
    :UNIT V | DBM | VRMS
```

Comments

- **[:SOUR]:VOLT POW CURR** Specify the type of signal source and amplitude characteristics. VOLT, POWer and CURRent are synonymous.
- **[:LEV]** Is an optional command which controls the signal amplitude level when the instrument is operating in a continuous or fixed mode.
- **[:IMM]** Is optional. The command is used to indicate that the next command should be processed without waiting for further commands.
- **[:AMPL]** This command is implied by a numeric value following the type (Volt, Current, Power) parameter. It sets the actual magnitude of the un swept output signal. The command may be used to specify the level for either a time varying or non time-varying signal. If :OFFSet is also specified, then [:AMPL] is used to specify a time-varied signal.
- **:VOLT:OFFS** Specifies the non time-varying component of a signal that is added to the time-varied signal specified by [:AMPL]. Offset is always specified in volts.
- **:VOLT:UNIT** Defines the default unit for amplitude and should therefore, precede the amplitude numeric value. This unit is also the unit in which queried values are reported.

[:SOURce]:AM

This command allows an external amplitude modulation signal to be applied to the synthesizer circuit of the HP E1440A.

Subsystem Syntax

```
[:SOURce]
  :AM
    :STATe   <boolean>
```

Parameters

Parameter Name	Parameter Type	Range of Values
ON|OFF|1|0	boolean	ON|OFF|1|0

Comments

- **External AM:** Is enabled with the :AM:STAT ON or :AM:STAT 1 command. Using this command does not automatically turn OFF any other external modulation signal that may be in use.
- **Disable AM:** Is disabled with the :AM:STAT OFF or :AM:STAT 0 command.
- **Related command:** *RST (sets to OFF).
- The command is only allowed with :FUNC SIN.

[:SOURce] :FREQuency

This command defines the frequency characteristics of an output signal.

Subsystem Syntax

```
[:SOURce]
  :FREQuency
    [:CW | FIXed] <numeric value>
    :MODE CW | FIXed | SWEep | LIST
    :STARt <numeric value>
    :STOP <numeric value>
    :CENTer <numeric value>
    :SPAN <numeric value>
      :HOLD <boolean>
      :LINK CENTer | STARt | STOP
      :FULL <event>
```

:FREQuency[:CW | :FIXed]

This command sets non-swept frequency of the instrument output signal. The value is specified by a digital number representing Hz i.e. 10000 specifies 10kHz.

:FREQuency:MODE

Determines which set of commands control the frequency subsystem. The settings have the following meanings:

- CW | FIXed: the frequency is determined by :FREQ[:CW] or :FREQ[:FIX].
- SWeep: The source is in swept mode and frequency is determined by :FREQ:STAR, :STOP, :CENT and :SPAN
- LIST: The source is in list sequence mode and frequency is determined by the :LIST:FREQ command.

:FREQuency :STARt :STOP

These two commands set the start and stop frequencies for a sweep. Changing the start frequency will change the centre and span settings but not the stop.

:FREQuency:CENTer

Sets the center frequency of a sweep. Changing the center frequency will alter the start and stop but not the span if the command is not accompanied by other commands. When more than two settings are issued in one message, only the last two will be effective.

:FREQuency:SPAN

This command sets the frequency span. Changing the span alters the start and stop but not center. When more than two span values are issued in one message, only the last two will be effective. The SPAN command has three sub commands as follows:

- **:FREQ:SPAN:HOLD** The hold command provides a facility for maintaining the span frequency as set, so that it is not altered by variations in other associated settings, such as STARt and CENTer. Hold has boolean values ON and OFF. When :HOLD:ON is specified, Span can only be changed by issuing a new :SPAN value.
- **:FREQ:SPAN:LINK** This command allows the default coupling for Span to be overridden. Link selects a parameter which is either CENTer, STARt or STOP, that shall not be changed when the value of SPAN changes. For example, if Link is set to STARt, then changing Span causes Center and Stop to change but not Start.
- **:FREQ:SPAN:FULL** When this command is received, the Start frequency is set to the minimum available value and Stop is set to the maximum value. This provides a sweep setting that encompasses the full instrument range. Center and Span will be set to their coupled values. :FULL is an event and therefore has no associated query or reset value.
- There is a difference between :FREQ:SPAN:FULL and :FREQ:SPAN MAX. The former command sets START to MIN and STOP to MAX whilst probably changing the SPAN and CENTER. The latter command enlarges the SPAN but maintains CENTER, i.e. SPAN expands equally either side of CENTER until either STARt or STOP reaches its currently allowed limit.

[:SOURce]:FUNCtion

The [:SOURce]:FUNCtion command subsystem controls the shape and attributes of the HP E1440A output signal.

Subsystem Syntax

[:SOURce]
  :FUNCtion
    [:SHAPe] DC | SINusoid | SQUare | TRIangle | RUP |RDOWn |TTL

Comments

The following signal characteristics may be specified using the :FUNCtion:SHAPe command:

- **:DC** The value is unchanging with respect to time.
- **:SINusoid** A sinusoidal waveform is specified.
- **:SQUare** A square wave signal is specified.
- **:TRIangle** A triangular (sawtooth) waveform is specified.
- **:RUP** The output signal will have the same frequency and amplitude as a TRI waveform but it steadily ramps upwards from zero and returns sharply to zero again.
- **:RDOWn** The output signal will steadily ramp downwards from zero, and returns sharply to zero again.
- **:TTL** The TTL function is somewhat different to all of the output functions because if FUNC = TTL, the main signal is disconnected (as if OUTP OFF). The only active signal output is the SYNC output. The purpose of FUNC TTL is to supply a TTL compatible signal on the SYNC output that has a much larger frequency range than the "true" output functions (1μHz to 60MHz).

[:SOURce]:LIST

The List command subsystem controls automatic sequencing through associated lists of specified signal values which are specified by the LIST command. The individual points defined in the list are combined to produce one composite signal configuration.

Subsystem Syntax

```
[:SOURce]
  :LIST
    :FREQuency
      :STARt  <numeric list>
        :POINts?  <query only>
      :STOP  <numeric list>
        :POINts?  <query only>
      :MARKer  <numeric list only>
        :POINts?  <query only>
        :STATe   <boolean list>
          :POINts?  <query only>
      :SPACing  <lin-log list>
        :POINts?  <query only>
    :DWELl   <numeric list>
      :POINts?  <query only>
    :SEQuence  <extended numeric list>
      :POINts?  <query only>
      :LENGth? <query only>
```

Note

The lists :FREQ:STAR | STOP | MARK, DWEL, SEQ, are not affected by *RST or SYST:PRE?? i.e. they do not change

:LIST:FREQuency

This command lists the frequency points of the list set. The command has several subsets as follows:

- **:FREQuency:STARt** is a numeric list of the start frequency for each sweep of a multiple sweep. For example :FREQ:STAR 5, 1000, 10500 would specify three sweeps with individual start frequencies of 5Hz 1 kHz and 10.5kHz.
- **:FREQ:STAR:POIN?** would return the number of entries in the START LIST.
- **:FREQuency:STOP** is a numeric list of the stop frequency for each sweep of a multiple sweep. This list must have an identical number of entries to the start list and vice versa, unless the same value applies to all entries, then the value need only be stated once and the parser will apply that value to each sweep in turn.

- **:FREQuency:MARKer** is a numeric list structured in the same way as start and stop lists. The :FREQ:MARK:STATe command can be used with ON and OFF entries to correspond with the markers you require to be present or one entry ON or OFF that applies to all markers.
- **:FREQuency:SPACing** is a list similar to the marker list but containing the entries LOG(arithmetic) or LIN(ear) as required. As with the other lists, the number of entries must be the same and in the same order or one common value.

:LIST:DWELl

This command list specifies the dwell time occurances for the frequency lists. The Dwell time is the sweep time for the corresponding interval.

:LIST:SEQuence

This command takes the form of an extended numeric list separated by commas, containing numbers and/or ranges as shown in the example

Example

5, 2, 3, 4, 5, 12 or

5, (2:5), 12 (equivalent)

These numbers define a sequence for stepping through a list. Individual points may be specified as many times as desired in a single sequence. The points specified by the command, are indexes into the lists. For example, if 3 was selected, the third point in the frequency, dwell, lists would be sequenced.The sequence list is separate and un associated with the other lists described above.

The command has two query functions associated with it:

- **:SEQuence:POINts?** This query returns the number of steps that would be sequenced at run time, not the number of entries in the sequence. Example: (1:5) ▸ 5
- **:SEQuence:LENGth?** This query returns the number of entries in the internal sweep sequence array. A number takes up one entry but a range takes up three entries. For example 1 (one entry), 2 (one entry), 3:10 (three entries) would return a length of 5. Although this value is of minor interest, it can be used to interrogate how much of the available sequence storage space (300 entries) has been used.

[:SOURce] :MARKer[<n>]

The :MARKer command subsystem selects between different marker, and adjusts the marker settings. The suffix <n> selects a particular marker number to which the command is applied. The default number is 1, the range is 1 to 9.

Subsystem Syntax

[:SOURce]

```
:MARKer [<n>]
  [:STATe]   <boolean>
  :FREQuency  <numeric value>
  :AOFF   <event>
```

Comments

- **:MARKer[:STATe]** ON|Off|1|0 enables or disables the specified marker.
  Parameters

Parameter Name	Parameter Type	Range of Values
ON|OFF|1|0	boolean	ON|OFF|1|0

- **:MARKer**[<n>]**:FREQuency** Controls the absolute frequency at which the marker will appear.
- **:MARKer:AOFF** Turns all markers off.

[:SOURce]:PHASe

The :PHASe command subsystem allows control of the phase of the output signal against a reference.

Subsystem Syntax

```
[:SOURce]
  :PHASe
    [:ADJust]  <numeric value>
      :STEP   <numeric value>
    :REFerence  <event>
    :UNIT   RADian | DEGree
```

Comments

- **:PHAse[:ADJust]** Controls the phase offset value relative to the reference. The command allows steps by substituting UP or DOWN for the parameter.
- **:PHASe[:ADJust]:STEP** Controls the step size in radians. A DEGree or RADian suffix can be applied.
- **:PHASe:REFerence** Is an event which allocates the current phase to be the reference for future phase adjustments. This function is non-query able.
- **:PHASe:UNIT** This command specifies the default unit (radian or degree). When querying a value without adding :UNIT?, only a numeric value will be returned. It is always advisable to use :UNIT?

Example:

:PHASe?;:PHAS:UNIT? <CR (return)>
may provide a response "24.3;DEG"

[:SOURce]:PM

The :PM command applies the phase modulation subsystem it is used to allow an external modulation signal to set the modulation controls of the HP E1440A and also the parameters associated with the modulating signal.

Subsystem Syntax

```
[:SOURce]
  :PM
    :STATe    <boolean>
```

Parameters

Parameter Name	Parameter Type	Range of Values
ON|OFF|1|0	boolean	ON|OFF|1|0

Comments

- **External PM:** Is enabled with the :PM:STAT ON or :PM:STAT 1 command. Using this command does not automatically turn OFF any other external modulation signal that may be in use.
- **Disable PM:** Is disabled with the :PM:STAT OFF or :PM:STAT 0 command.
- **Related command:** *RST (sets to OFF).

[:SOURce] :ROSCillator

The :ROSCillator command subsystem controls the reference oscillator.

Subsystem Syntax

```
[:SOURce]
  :ROSCillator
    :SOURce   INTernal | EXTernal | CLK 10
    :AUTO   <boolean> | ONCE
```

Comments

- **:ROSC:SOUR** Controls selection of the oscillator to which the HP E1440A is to be locked. The parameters have the following meanings:
  - **INTernal** The internal crystal reference source is used.
  - **EXTernal** The HP E1440A is locked to an external reference source applied via the BNC connector on the front panel. If no external reference signal can be detected, then the command is rejected and an error is generated. The signal toggles to INT if EXT is specified again when the command is re-programmed. This default is necessary in case the external source has been removed.
  - **CLK 10** The 10 MHz VXIbus mainframe generated reference is applied via the bus interface.
- **:ROSC:AUTO** The instrument determines what reference to use by the following algorithm:
  if external ref is detected, then use EXTERNAL
  else
  use INTERNAL.

[:SOURce]:SWEep

The :SWEep command subsystem controls the generation of a sweep signal output

Subsystem Syntax

```
[:SOURce]
  :SWEep
    :TIME    <numeric value>
    :RETRace  <numeric value>
      :AUTO   <boolean> | ONCE
    :DIRection  UP | DOWN
```

:SWEep:TIME

This command sets the duration of the sweep. Using this command does not turn sweeping on, it merely specifies duration.

:SWEep:TIME:RETRace

This command is similar to :TIME and sets the duration of the sweep retrace time.

Comments

- **:SWE:TIME:RETRace;** Defines the retrace time for SWEep and LIST
- **:SWEep:TIME:RETRace:AUTO** has the following parameters:
  - **ON:** RETRace adopts the same value as TIME and follows any change in the value of TIME.
  - **OFF:** RETRace is independent from TIME. Setting RETRace via the SWE:RETRace <num> command, switches AUTO to OFF.
  - **ONCE** Is equivalent to :AUTO:ON;:AUTO:OFF, then RETRace follows TIME and AUTO is OFF.

:STATus

This command is a reporting command which allows examination and manipulation of the various HP E1440A status registers. Appendix B *Register Programming* explains the relationship and use of these registers. The commands to access each register are always the same and are described below.

:STATus:OPERation

This command allows access to the Operation Status register as detailed below in the syntax list.

Subsystem Syntax

```
STATus
  :OPERation
    [:EVENt]?
    :CONDition?
    :ENABle <integer number>
    :ENABle?
    :PTRansition <integer number>
    :PTRansition?
    :NTRansition <integer number>
    :NTRansition?
```

Comments

- **[:EVENt]?** This query returns the contents of the event register associated with the status structure defined in the command.

Note

Reading the event register automatically clears it's contents

- **:CONDition** This query returns the contents of the condition register associated with the status structure defined in the command. Reading the condition register is non-destructive.
- **:ENABle <integer number>** Sets the enable mask which allows true conditions in the event register, to be reported in the summary bit. If a bit in the enable register is a "1", and it's associated event bit undergoes a transition to true, a positive transition will occur in the associated summary bit.

  The parameter is a decimal number.
- **:ENABle?** This command is the query form of the above command, it always returns an <integer number> value.
- **:PTRansition <integer number>**: Sets the positive transition filter. After setting a bit in the positive transition filter, a "0" to "1" transition in the corresponding bit of the associated condition register, causes a "1" to be written to the associated bit of the corresponding event register.

  The parameter is a decimal number.

- **:PTRansition?** This command is the query form of the above command, it always returns an <integer number> value.
- **:NTRansition <integer number>**: Sets the negative transition filter. After setting a bit in the negative transition filter, a "1" to "0" transition in the corresponding bit of the associated condition register, causes a "1" to be written to the associated bit of the corresponding event register.

  The parameter is a decimal number.
- **:NTRansition?** This command is the query form of the above command, it always returns an <integer number> value.

:STATus:QUEStionable

This command allows the same operations on the QUESTIONABLE status register, as on the OPERATIONAL status register. The same list of sub commands are valid.

:STATus:QUEStionable :FREQUENCY

This command allows the same operations on the QUESTIONABLE FREQUENCY status register, as on the OPERATIONAL status register. The same list of sub commands are valid.

:STATus:PRESet

This command allows the status registers to be pre loaded with the following bit patterns.

Table 5-1. Operation Status Register

ENAB	All	0
PTR	All	1
NTR	All	0

Table 5-2. Questionable Status Register

ENAB	All	0
PTR	All	1
NTR	All	0

:STATus

Table 5-3. Questionable Frequency Register

ENAB	All	0
PTR	Bit 2 (main VCO unlock)	1
	All others	0
NTR	All	0

:SYSTem

This command collects the functions that are not related to instrument performance, for example those that perform general houskeeping and contain information.

Subsystem Syntax

:SYSTem

:ERRor? <query only>
:PRESet <event>
:VERSion? <query only>

:SYSTem:ERRor?

The ERRor? command is a request for an error message from the error queue in the HP E1440A. This queue contains integers related to the type of error encountered (if any), in the form of an error number followed by a string describing the error and/or device dependent information. For example *-222, "Data out of range; Start Frequency is too low"*. Maximum length of a string is 255 characters.

The integer ranges from −32768 to 32767 and individual numbers within this range are fixed to, or reserved for, specific errors. In general, negative error numbers tend to be associated with command syntax type errors such as conflict between values specified within a command, which would cause execution errors. Positive error numbers are associated with instrument errors, whether they are hardware faults or attempts to 'misuse' the instrument. A zero value signifies NO ERRORS.

Refer to Appendix E *Error Messages* for details of error strings.

As errors occur they are placed in an error queue on a FIFO (first in first out) basis from which they are read by the system controller.

:SYSTem:PRESet

This command sets the HP E1440A to its "local" state in a similar manner to *RST (see following section on IEEE 488.2 Commands).

:SYSTem:VERSion?

The VERSion? command is a query only command that returns a language version identity with which the instrument parser is compatible i.e. it returns the level of SCPI with which it complies.

IEEE 488.2 Commands for the HP E1440A

Table 5-4. Common Command Summary

Command	Function
*CLS	Clear Status
*ESE	Standard Event Status Enable
*ESE?	Standard Event Status Enable Query
*ESR?	Standard Event Status Register Query
*IDN?	Identification Query
*OPC	Operation Complete
*OPC?	Operation Complete Query
*RCL<n>	Recall setting n
*RST	Reset
*SAV<n>	Save setting n
*SRE	Service Request Enable
*SRE?	Service Request Enable Query
*STB?	Read Status Byte Query
*TST?	Self Test Query
*WAI	Wait to Continue

*CLS

Clear status command.

Syntax

```
*CLS
```

Definition

The *CLS command clears the following:

- Error queue
- Standard event status register (ESR)
- Status byte register bit 5 (STB)
- A service request
- OCAS and OQAS (see IEEE 488.2 specification)

No changes are made to the following:

- Status byte register bits 6, 4, 2-0 (STB)
- Output queue
- Event status enable register (ESE)
- Service request enable register (SRE)

After the `*CLS` command the instrument is left in the idle state. The instrument setting is unaltered by the command, though `*OPC`/`*OPC?` actions are canceled.

If the *CLS command occurs directly after a program message terminator, the output queue and MAV, bit 4, in the status byte register are cleared, and if condition bits 2-0 of the status byte register are zero, MSS, bit 6 of the status byte register is also zero.

Related Command

`SDC`

Example

```
OUTPUT 70911;"*CLS"
```

*ESE

Standard event status enable command.

Syntax

*ESE <value>
$0 \leq$ value ≤ 255

Definition

The *ESE command sets bits in the standard event status enable register (ESE) which enable the corresponding bits in the standard event status register (ESR).

The register is cleared:

- At power-on
- By sending a value of zero

The register is not changed by the *RST and *CLS commands.

BIT	MNEMONIC	BIT VALUE
7	PON	128
6	Not used	0
5	CME	32
4	EXE	16
3	DDE	8
2	QYE	4
1	Not used	0
0	OPC	1

The Event Status Enable Register

Related Commands

*ESE?

Example

```
OUTPUT 70911;"*ESE 21"
```

*ESE?

Standard event status enable query.

Syntax

*ESE?

Definition

The standard event status enable query returns the contents of the standard event status enable register.

$0 \leq \text{contents} \leq 255$

BIT	MNEMONIC	BIT VALUE
7	PON	128
6	Not used	0
5	CME	32
4	EXE	16
3	DDE	8
2	QYE	4
1	Not used	0
0	OPC	1

The Event Status Enable Register

Related Commands

*ESE

Example

```
OUTPUT 70911;"*ESE?"
ENTER 70911; A$
PRINT ;A$
```

*ESR?

Standard event status register query.

Syntax

*ESR?

Definition

The standard event status register query returns the contents of the standard event status register. The register is cleared after being read.

$0 \leq \text{contents} \leq 255$

BITS	MNEMONICS	BIT VALUE
7	PON	128
6	Not used	0
5	CME	32
4	EXE	16
3	DDE	8
2	QYE	4
1	Not used	0
0	OPC	1

The Standard Event Status Register

Related Commands

None.

Example

```
OUTPUT 70911;"*ESR?"
ENTER 70911; A$
PRINT ;A$
```

*IDN?

Identification query.

Syntax

`*IDN?`

Definition

The identification query commands the instrument to identify itself over the interface.

Response: `HEWLETT-PACKARD, E1440A, 0, n.n`

`HEWLETT-PACKARD`:	manufacturer
`E1440A`:	instrument model number
`0`:	indicates serial numbers are not provided.
`n.n`:	firmware revision level

Related Commands

None.

Example

```
DIM A$ [100]
OUTPUT 70911;"*IDN?"
ENTER 70911; A$
PRINT A$
```

*OPC

Operation complete command.

Syntax

*OPC

Definition

If "*OPC" is sent to the HP E1440A while a sweep is running, then the OPC-bit in the standard event status register is set when the current sweep stops. If no sweep is running at the time *OPC is sent to the HP E1440A the bit is set immediately.

The following actions cancel *OPC (device goes to Operation Complete, Command Idle State):

- Power-on
- the *dcas* line on the interface is asserted.
- *CLS
- *RST

Related Commands

*OPC?, *WAI

Example

```
OUTPUT 70911;"*CLS;*ESE 1;*SRE 32"
OUTPUT 70911;"*OPC"
```

*OPC?

Operation complete query.

Syntax

`*OPC?`

Definition

If a sweep is currently driving the instrument, the command parser prevents any further commands from being processed. When the sweep stops, ASCII character '1' is placed in the output queue and the instrument processes further commands.

If no sweep is running, ASCII '1' is immediately placed in the output

Caution

If this command is used carelessly, the instrument may appear to have entered a "hung up" state because:

Sweeps can be very long, especially in LIST
Continuous sweeps do not stop!

This means that a **Device clear** command or **Selected Device Clear** command must be sent to the instrument if the succeeding commands are to be executed (see example below)

The following actions cancel *OPC? (device goes to Operation Complete, Command Idle State):

- Power-on
- the *dcas* line on the interface is asserted
- *CLS
- *RST

Related Commands

*OPC, *WAI

Example 1

```
OUTPUT 70911;"*OPC?"
ENTER 70911;A$
PRINT A$
```

Example 2

```
1000 ! E1440A is set at HPIB address 70911
1010 ! (Select code of controller HPIB interface card is 7)
1020 ! (Primary HPIB address of slot 0 commander is 09)
1030 ! (E1440A logical address = 88 right shifted 3 bits is 11)
1040 !
1050 CLEAR 7      ! All instruments connected to bus receive DCL
1060 ! 0V
1070 CLEAR 70911      ! Only the HP E1440A receives SDC
```

*RCL

Recall command

Syntax

*RCL <n>

($0 \leq n \leq 9$)

Definition

Recall an instrument set-up from one of the 10 memories. Note that all the instrument's memories are reset to the default settings by the *RST command.

Related Command

*SAV,*RST

Example

```
OUTPUT 70911;"*RCL 3"
```

*RST

Reset command.

Syntax *RST

Caution

The *RST command will overwrite all instrument set-ups stored in the instrument memories.

Definition

The reset setting (standard setting) stored in ROM is made the current instrument setting, and is also stored in all the instrument's memories.

Pending *OPC/*OPC? actions are cancelled.

Instrument state: the instrument is placed in the idle state awaiting a command.

The following are not changed:

- VXIbus (interface) state
- Instrument interface address
- Output queue
- Service request enable register (SRE)
- Standard event status enable register (ESE)
- Lists

The commands and parameters of the reset state are listed in the following table.

Table 5-5. Reset State (Standard Setting)

Parameter	Reset State
INIT:CONT	OFF
VOLT	1 mV
VOLT:OFFS	0 V
VOLT:UNIT	V
FREQ	0 Hz
FREQ:MODE	CW
FREQ:STAR	0 Hz
FREQ:STOP	21 MHz
FREQ:SPAN:HOLD	OFF
FREQ:SPAN:LINK	CENT
MARK <n>	OFF (n is 1 to 9)
MARK <n>:FREQ	0 Hz (n is 1 to 9)
SWE:TIME	1 s
SWE:TIME:RETR:AUTO	ON
SWE:DIR	UP
ROSC:SOUR	INT
ROSC:AUTO	ON
FUNC	SIN
AM:STAT	OFF
PM:STAT	OFF
OUTP	OFF
OUTP:AMPL	OFF
OUTP:TTLT <n>	OFF (n is 0 to 7)
OUTP:TTLT <n>:SOUR	SYNC (n is 0 to 7)
PHAS	0 DEG
PHAS:STEP	1 DEG
PHAS:UNIT	RAD
*SAV <n>	(n is 0 to 9)

Related Commands None.

Example `OUTPUT 70911;"*RST"`

*SAV

Recall command

Syntax

*SAV <n>

$(0 \leq n \leq 9)$

Definition

Save the instrument set-up to one of the 10 memories. Note that the instrument's memories are reset to the default settings by the *RST command.

Related Command

*RCL,*RST

Example

```
OUTPUT 70911;"*SAV 3"
```

*SRE

Service request enable register.

Syntax

*SRE <value>

$0 \leq \text{value} \leq 255$

Definition

The service request enable command sets bits in the service request enable register which enable the corresponding status byte register bits.

The register is cleared:

- At power-on
- By sending a value of zero.

The register is not changed by the *RST and *CLS commands.

BITS	MNEMONICS	BIT VALUE
7	Operational status summary bit	0
6	RQS/MSS	64
5	ESB	32
4	MAV	16
3	Not used	0
2	Not used	0
1	Not used	0
0	Not used	1

The Service Request Enable Register

Related Commands

*SRE?, *STB?

Example

```
OUTPUT 70911;"*SRE 48"
```

*SRE?

Service request enable query.

Syntax

*SRE?

Definition

The service request enable query returns the contents of the service request enable register.

$0 \leq \text{contents} \leq 255$

BITS	MNEMONICS	BIT VALUE
7	Operation status summary bit	0
6	RQS/MSS	64
5	ESB	32
4	MAV	16
3	Not used	0
2	Not used	0
1	Not used	0
0	Not used	1

The Service Request Enable Register

Related Commands

*SRE, *STB?

Example

```
OUTPUT 70911;"*SRE?"
ENTER 70911; A$
PRINT ;A$
```

*STB?

Read status byte query.

Syntax

```
*STB?
```

Definition

The read status byte query returns the contents of the status byte register.

$0 \leq$ contents ≤ 255

The MSS message is reported in bit six of the status byte register.

BITS	MNEMONICS	BIT VALUE
7	Operational status summary bit	0
6	MSS	64
5	ESB	32
4	MAV	16
3	Not used	0
2	Not used	0
1	Not used	0
0	H	1

The Status Byte Register

Related Commands

*SRE, *SRE?

Example

```
OUTPUT 70911;"*STB?"
ENTER 70911; A$
PRINT ;A$
```

*TST?

Self-test query.

Syntax

```
*TST?
```

Definition

The self-test query commands the instrument to perform a self-test and place the results of the test in the output queue.

Returned value: $0 \leq$ value ≤ 256.

A value of zero indicates no errors.

A non-zero result places one or more errors in the error queue.

No further commands are allowed while the test is running.

The instrument is returned to the setting that was active at the time the self-test query was processed.

The self-test does not require operator interaction beyond sending the *TST? query.

Related Commands

None.

Example

```
OUTPUT 70911;"*TST?"
ENTER 70911; A$
PRINT ;A$
```

Results

The *TST? response consists of one byte. The significance of each bit is illustrated below.

Bit	Meaning
Bit 0 (1)	ROM test failed. The signature word in the ROM stored there at manufacture does not match the one generated at test time.
Bit 1 (2)	RAM test failed. Not all RAM cells can be written and/or read properly.
Bit 2 (4)	Device bus test failed. It is not possible to access the instruments hardware properly.
Bit 3 (8)	Software timer test failed. The 10 ms interrupt signal used for software scheduling purpose is missing or the period of the signal (compared indirectly to the μP processor clock) is out of tolerance. ATTENTION : this test is not done in the initial power up self test.
Bit 4 (16)	Sweep timer test failed. The 1 ms interrupt signal used during equi - (start freq. = stop freq.) or logarithmic sweeps is missing, or the period of the signal (compared indirectly to the μP processor clock) is out of tolerance. ATTENTION : this test is not done in the initial power up self test.

Bit 5 (32)	The amplitude calibration test failed. Something in the analog level generation / mixer / amplifier circuitry is not OK.
Bit 6 (64)	Fractional-N IC test failed. The fractional-N chip (heart of the synthesizer) can not be accessed or does not work properly.
Bit 7 (128)	VCO test failed. The voltage controlled oscillator does not lock.
Bit 8 (256)	Self test was called while instrument was in :FREQ:MODE SWEEP or LIST. This is a meta-error message, the self test did not fail—it is just illegal to call it in :FREQ:MODE SWEEP/LIST. Note that no self test has been done!

*WAI

Wait to continue command.

Syntax

```
*WAI
```

Definition

If a sweep is currently driving the instrument, the command parser prevents any further commands from being processed. When the sweep stops, the instrument processes any further commands.

If no sweep is running, the instrument immediately processes further commands

Caution

If this command is used carelessly, the instrument may appear to have entered a "hung up" state because:
Sweeps can be very long, **especially in LIST !**
Continuous sweeps do not stop!

This means that a **Device clear** command or **Selected Device Clear** command must be sent to the instrument if the succeeding commands are to be executed (see example 2 below)

The following actions cancel *WAI (device goes to Operation Complete, Command Idle State):

- Power-on
- the *dcas* line on the interface is asserted
- *CLS
- *RST

Related Commands

*OPC, *OPC?

Example 1

```
OUTPUT 70911; "*WAI"
```

Example 2

```
1040 !
1050 CLEAR 7      ! All instruments connected to bus receive DCL
1060 !
```

A

Specifications

All specifications apply after a 30 minute warm-up period, and are valid from 0°C to 55°C ambient temperature. All specifications describe the warranted performance, except those listed below:

Typical

The following specifications are typical, not absolute: Main Signal Output, Squarewave Characteristics (also by Option 001), Auxiliary Outputs, Auxiliary Inputs, HP-IB Control and General specifications, which describe the typical performance.

Waveforms

Sine, square, triangle, negative and positive ramps, DC and TTL clock.

Frequency

Range

Sine:	1 μHz - 21 MHz
Square:	1 μHz - 11 MHz
Triangle:	1 μHz - 11 kHz
Ramps:	1 μHz - 11 kHz
TTL clock:	1 μHz - 60 MHz

Resolution:

1 μHz, upto 100 kHz
1 mHz at 100kHz and greater frequencies

Accuracy:

±5 ppm of selected value, from 20°C to 30°C, at time of calibration with standard frequency reference.

Stability:

±5 ppm/year, from 20°C to 30°C

Main Signal Output (Typical)

Impedance:
50Ω±1Ω, 0–10 kHz

Return Loss:
> 20 dB, 10 kHz to 20 MHz, except > 10 dB for > 3 V, 5 MHz to 20 MHz.

Floating:
Chassis ground to circuit ground:
Output may be floated upto 42 V peak (AC + DC)
Max. external voltage, floating ground to signal output: ±10 V

Connector:
BNC

Amplitude into 50Ω

(All waveforms without DC offset, except TTL clock).

Range:
1 mV to 10 V(p-p) in 8 amplitude ranges, 1-3-10 sequence, amplitude can also be set up in **rms** and **dBm**.

Ranges (without DC offset):

1 mV – 2.999 mV	100 mV – 299.9 mV
3 mV – 9.999 mV	300 mV – 999.9 mV
10 mV – 29.99 mV	1 V – 2.999 V
30 mV – 99.99 mV	3 V – 10.00 V

Resolution:
4 digits (0.03% of full range).

Function	peak-to-peak	rms	dBm (50Ω)
Sine			
min.	1.000 mV	0.354 mV	−56.02
max.	10.00 V	3.536 V	+23.98
Square			
min.	1.000 mV	0.500 mV	−53.01
max.	10.00 V	5.000 V	+26.99
Triangle/ Ramps			
min.	1.000 mV	0.289 mV	−57.78
max.	10.00 V	2.887 V	+22.22

Accuracy (with 0 Vdc offset):

Sinewave:

	<100 kHz	>100 kHz to 10 MHz	>10 MHz to 20 MHz
+23.98 to 13.52 dBm	±0.2 dB	±0.4 dB	±0.4 dB
<+13.52 to −16.02 dBm	±0.2 dB	±0.6 dB	±0.6 dB
<−16.02 to −56.02 dBm	±0.2 dB	±0.6 dB	±0.9 dB

Squarewave:

	<100 kHz	>100 kHz to 10 MHz
10 V(p-p) to 3 V(p-p)	±1.5%	±5%
<3 V(p-p) to 1 mV(p-p)	±2.2%	±10%

Triangle:

	<2 kHz	>2 kHz to 10 kHz
10 V(p-p) to 3 V(p-p)	±1.5%	±5.0%
<3 V(p-p) to 1 mV(p-p)	±2.7%	±6.2%

Ramps:

	<500 Hz	>500 Hz to 10 kHz
10 V(p-p) to 3 V(p-p)	±1.5%	±10.0%
<3 V(p-p) to 1 mV(p-p)	±2.7%	±11.2%

With DC offset, increase all sinewave tolerances by 0.2 dB and all function tolerances by 2%.

Sinewave Spectral Purity

Phase Noise:
−55 dB for a 30 kHz band centered on a 20 MHz carrier (excluding ±1 Hz about the carrier).

Spurious:
All non-harmonically related output signals will be more than 60 dB below the carrier, (−55 dBc with DC offset), or less than −85 dBm, whichever is greater.

Sinewave Harmonic Distortion:
Harmonically related signals will be less than the following levels relative to the fundamental:

Frequency Range	Harmonic Level
0.1 Hz – 199 kHz	−60 dBc
200 kHz – 1.99 MHz	−40 dBc
2 MHz – 14.9 MHz	−30 dBc
15 MHz – 20 MHz	−25 dBc

Squarewave Characteristics (Typical)

Rise/Fall Time:
(10% to 90% of p-p output voltage): ≤20 ns

Overshoot:
5% of peak-to-peak amplitude at full output.

Symmetry:
≤0.02% of period +3 ns.

Triangle/Ramp Characteristics

Linearity:
(10% to 90%, 10 kHz): ±0.05% of full peak-to-peak output voltage for each range.

Ramp Retrace Time (typical):
(10% to 90%): ≤3 μs

Period Variation for Alternate Ramp Cycles (typical):
≤1% of period.

DC Offset

Range:
DC only (no AC signal): 0 to ±5 V / 50Ω
DC + AC: Maximum DC offset ±4.5 V on highest range; decreasing to ±4.5 mV on lowest range.

Resolution:
4 digits

Accuracy:
DC only: ±0.015 mV to ±50 mV, depends on offset chosen, ±0.02 mV.
DC + AC, upto 1 MHz: ±0.06 mV to ±60 mV, depends on AC output level; ±0.2 mV to ±120 mV for triangle and ramps to 10 kHz.

DC + AC, from 1 MHz to 20 MHz: ±15 mV to ±150 mV, depends on AC output level.

Phase Offset

Range:
719.9° with respect to arbitrary starting phase or assigned zero phase. For squarewave frequencies below 25 kHz, phase changes greater than 25° may result in a phase shift of ±180° from the desired amount.

Resolution:
0.1°

Increment Accuracy:
±0.5°

Stability:
±1.0° of phase/°C

Sinewave Amplitude Modulation (Typical)

Modulation Depth (at full output for each range):
0 - 98%

Modulation Frequency Range:
DC to 350 kHz (1μHz-21 MHz carrier frequency)

Envelope Distortion:
−30 dB for modulation to 80% at 1 kHz, 0 Vdc offset

Sensitivity:
±5 V peak for maximum modulation

Phase Modulation (Typical)

Sinewave Range
±900°, ±5 V input

Sinewave Linearity
±0.5%, best fit straight line upto ±720° of modulation range
±1%, best fit straight line >±720°

Squarewave Range
±450°

Triangle Range
±45°

Positive and Negative Ramps Range
±90°

Modulation Frequency Range
DC - 5 kHz

Frequency Sweep

Sweep Sequence Modes:
Single, continuous.

Sweep Function Modes:

Multi - Interval:
Upto 50 **different** intervals can be sequenced and repeated in any order in a sequence which can contain upto 100 intervals.

Frequency-switching-time between intervals (typical):
≤2 ms for a 100 kHz step.
≤3 ms for a 1 MHz step.
≤20 ms for a 20 MHz step.

Linear Sweep	**(settable for each interval)**
Sweep time	0.01 s to 10^5 s
Maximum sweep width	full frequency range of the main signal output for the waveform in use.
Minimum sweep width	0 Hz
Minimum sweep rate	0.2 Hz/s

One marker frequency can be set in each interval.

Logarithmic Sweep (sweep up only)	**(settable for each interval):**
Sweep time	0.1 s to 10^5 s
Maximum sweep width	full frequency range of the main signal output for the waveform in use.
Minimum start frequency	1 Hz
Minimum sweep width	1 decade

Multi Marker:

Linear sweep (only)	
Sweep time	0.01 s to 10^5 s
Maximum sweep width	full frequency range of the main signal output for the waveform in use.
Minimum sweep width	0 Hz

Upto 9 markers can be set in this one, dedicated, interval.

Phase Continuity:
Sweep is phase continuous over the full frequency range of the main output for all sweep modes.

Auxiliary Outputs (Typical)

Floating:
Chassis ground to circuit ground: Output may be floated upto 42 V peak (AC & DC)

SYNC-OUT TTL:
1 μHz to 21 MHz phase synchronous squarewave with the same frequency as the main signal output,
or 1 μHz to 60 MHz TTL Clock (main signal output switched off).
Output impedance: 50Ω
Output levels: high level > 2 V, low level < 0.2 V
Connector: BNC and trigger bus.
Note: Level doubles into open input.
Max. external voltage: 0 V to +5 V, floating ground to output signal

X DRIVE 0–10V:
(0 – 100 s sweeps only).
The ramp is proportional to the entire sweep time, including each individual interval sweep time and the switching times between intervals.
Output impedance: 650 Ω
Output level: 0 to +10 V (into open circuit)
Connector: BNC.
Max. external voltage: ±10 V, floating ground to output signal

PEN LIFT:
TTL compatible voltage levels capable of sinking current from a positive source. Current 200 mA, voltage 45 V
Connector: BNC.
Max. external voltage: 0 V to +45 V, floating ground to output signal

MARKER TTL:
High to low transitions at selected marker frequencies. TTL and CMOS compatible output levels.
Pulsewidth in Multi-Marker mode: 1 ms.
Connector: BNC and trigger bus.
Fan out: 4
Max. external voltage: 0 V to +5 V, floating ground to output signal

REF OUT 10 MHz
10 MHz squarewave for phase locking additional instruments to the HP E1440A.
Output impedance: 50Ω
Output levels (into 50Ω): high level > 2V, low level <0.2V
AC-coupled output levels: 10 dBm
Connector: BNC.
Max. external voltage: 0 V to +5 V, floating ground to output signal

Auxilliary Inputs (Typical)

External REF IN 1/10 MHz
For phase locking the HP E1440A to an external frequency reference.
Signal from 0 dBm to 20 dBm into 50Ω
Reference signal must be a sub-harmonic of 10 MHz from 1 MHz to 10 MHz.
Connector: BNC or VXI-system clock

AM:
Input Impedance: 10 kΩ
Connector: BNC
Max. external voltage: ±15 V

PM:
Input Impedance: >40 kΩ
Connector: BNC
Max. external voltage: ±15 V

VXIbus Interface Capabilities

Message based servant:
A16/A24 D16 Master
A16 D16 Slave

Option 001 High-Voltage Output Amplifier

Frequency range:
1 μHz to 1 MHz

Amplitude:
4 mV to 40 V(p-p) in 8 ranges, 4–12–40 sequence into 500Ω, < 500 pF load. Ranges are four times the standard instrument ranges, without DC offset.
Accuracy: ±2% of full output for each range at 2 kHz.
Flatness: ±10% relative to programmed amplitude.

Sinewave Harmonic Distortion:
Harmonically related signals will be less than the following levels (relative to the fundamental full output into 500Ω, 500 pF load):

Frequency Range	Harmonic Level
10 Hz – 199 kHz	–60 dBc
200 kHz – 1 MHz	–40 dBc

Squarewave Rise/Fall Time (typical):
≤125 ns, 10% to 90% of peak-to-peak output voltage with 500Ω, 500 pF load.

Squarewave Overshoot (typical):
≤10% of peak-to-peak output voltage with 500Ω, 500 pF load.

Output Impedance:
< 3Ω at DC, < 10Ω at 1 MHz.

DC Offset:
Range: 4 times the specified range of the standard instrument.
Accuracy: ±(1% of full output voltage for each range + 25 mV).

Maximum Output Current:
±40 mA peak.

General (Typical refer to VXI System Specification)

Module Size: C

Number of Slots: two (2)

Connectors Used: P1, P2

Device Type: Message-based

Watts/Slot: 18 W

Cooling/Slot
Air flow: 2.0 litres/second, pressure 0.4 mm H_2O

Operating Environment:

Relative humidity: 65%, 0°C to 40°C
Operating temperature: 0°C to 55°C
Storage temperature: −40°C to +75°C

EMC:
Module meets FTZ 1046/1984, IEC 348 (safety class III)

Weight: 4 kg net, 6.5 kg shipping.

Power Requirements:

DC Volts	DC Current	Dynamic Current
+5 V	1 A	10 mA
+24 V	0.55 A	50 mA
−24 V	0.6 A	50 mA
−5.2 V	0.14 A	30 mA

B

Register Programming

Registers

There are two sets of associated registers:

- VXIbus standard configuration registers - these are part of the VXIbus mainframe configuration and therefore are not discussed here, information can be obtained from the VXIbus System Specification.
- Device dependent or slave registers - these registers are provided in the HP E1440A and are the subject of this manual appendix.

Status Reporting

The HP E1440A supports SCPI standard status register configuration, as defined in IEEE 488.2

Error Queue

The instrument maintains an error queue according to the SCPI standard. The error queue is able to queue up to 30 errors.

Status Registers

The HP E1440A has a set of status registers that can be interrogated by the controller. Any error conditions which are contained in these registers are also entered in the error queue. If required, registers can be pre-loaded with values which will mask out certain conditions. The registers are identified as follows:

Register	Contents (Flags)
Quest. Frequency	Ext ref missing, Ext ref unlocked, Main VCO unlock
Quest. Status	Voltage, Freq.
Standard Event Status	Operation complete, Query error, Dev. dep. error, Execution error, Command error, Power on
Operation Status	Calibrating, Sweeping
Status Byte	Quest. summary, MAV, ESB, RQS, Operational summary

The inter-relationship between the status registers is shown in Figure B-1 below

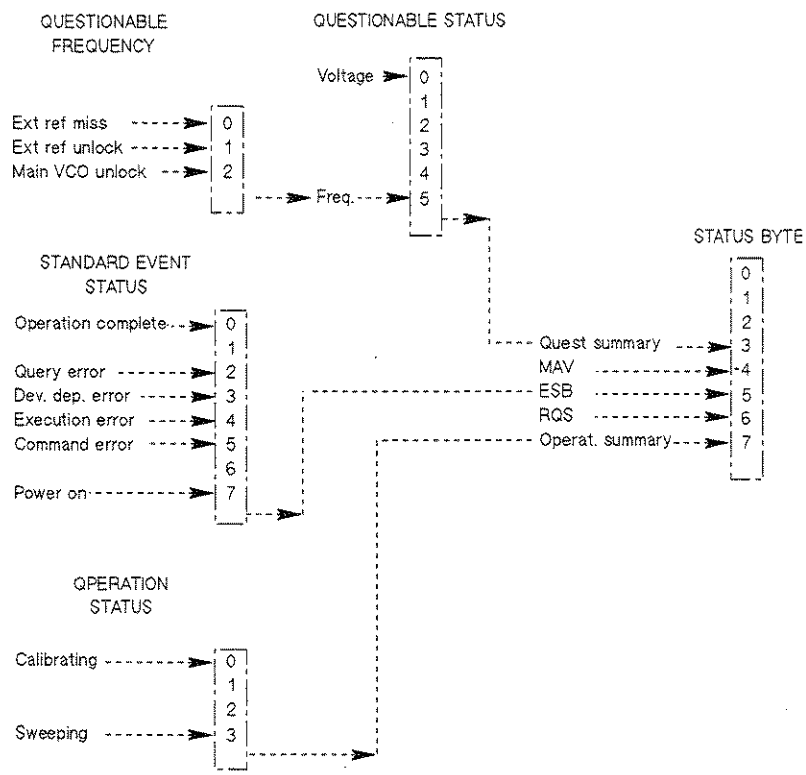

Figure B-1. Status Register Subset

Using the Registers

Communication with the registers is accomplished by reads and writes of the register contents. The methods are fully described in Chapter 5 *Command Reference* in the explanation of the :STATUS command

The bits pointed to by arrows (—▶) are maintained by the instrument. The other bits are unused and always read as zero. Most of the status bits are defined by and fully explained, in the SCPI standard. Only the QUESTIONABLE bits which are exclusive to the HP E1440A need explanation here.

Signal	**Explanation**
Ext ref miss	This condition is set when no AC signal is detected at front panel 'Ext Ref in' connector, otherwise bit is cleared. The condition is checked every 0.2 seconds.
Ext ref unlock	If the reference source is EXT or VBUS, this condition is set when the reference oscillator is unable to lock itself to the source.

If the reference source is INT this condition is always set.
The condition is checked every 0.2 seconds.

Main VCO unlock	This condition is set when the main VCO loop is out of lock, indicating a hardware fault. The condition is checked every 0.2 seconds.
Voltage	This condition is set when the instrument is unable to do a successful amplitude calibration, indicating a hardware fault. It is updated every time a amplitude calibration is done (explicit by command CAL? or implicit by a change of the output function).

Sample Program

This example RMBASIC program demonstrates the use of the E1440A Status registers. The program does the following :

Forms two BASIC SUB's -

Status_init(Address) and
Err_check(Address)

These SUB's might be helpful during test program development. Status_init should be called at the beginning, For quick debugging, Err_check might be called after each programming cycle of the E1440A.

Note

A common problem must be overcome here: we have to ensure that the E1440A has seen all commands before looking for errors. The *OPC? command is ideal for this.
For easy ON/OFF switching we define a common named 'debug' to control the behavior of the SUB's

Program

```
10    COM /Debug/ INTEGER Err_check
20    REAL E1440                ! for the instrument VXIbus address.
30                              ! Notice that an INTEGER is too small to hold
40                              ! a VXIbus address with secondary addressing.
50    !
60    E1440=70911               ! assumed slot 0 commander is connected to
70                              ! VXIbus interface with select code 7,
80                              ! primary VXIbus address of slot 0 commander is 9
90                              ! and logical address of E1440A is 88 (secondary
100                             ! VXIbus address is logical add. shifted left 3 bits)
110    !
120    Err_check=1           ! we want to do error checking, set to 0 if You don't
130    !
```

```
140   ! At the start we put instrument into known state.
150   CLEAR E1440
160   OUTPUT E1440;"*RST; :STATUS:PRESET; *CLS"
170   !
180   ! Prepare status system.
190   !
200   CALL Status_init(E1440)
210   !
220   ! Now some commands with immediate error checking.
230   !
240   OUTPUT E1440;":FUNCT SIN;"      ! Oops - it should be 'FUNC' or 'FUNCTION'
250   CALL Err_check(E1440)
260   !
270   OUTPUT E1440;":VOLT 3; :FREQ:MODE SWEEP"
280   CALL Err_check(E1440)
290   !
300   OUTPUT E1440;":FREQ:START 2 KHZ" ! ':FREQ:START' not allowed in mode SWE
310   CALL Err_check(E1440)
320   !
330   END
340   !
350   !
360   SUB Status_init(REAL Addr)
370   Status_init:  ! Just for finding SUB via 'edit status_init'
380     COM /Debug/ INTEGER Err_check
390   !
400     IF NOT Err_check THEN SUBEXIT         ! hurry back
410   !
420     OUTPUT Addr;"*ESE 60;"! 60 = 00111100 bin --> all error bits
430                           ! are enabled, thus propagated into the
440                           ! status bytes bit #5 (ESB)
450     OUTPUT Addr;"*SRE 32;"! 32 = 00100000 bin --> ESB bit
460                           ! will be propagated into bit 6 (RQS)
470                           ! of the status byte.
480   ! with this setup an error can be detected very quickly
490   ! because ESB is the only bit that causes RQS and the error
500   ! bits in the standard event status byte are the only
510   ! bits that will propagate into the status byte.
520   ! In other words: every time RQS is set there will be an error.
530   ! The RQS bit can be checked very quickly using the SPOLL command.
540   SUBEND
550   !
560   !
570   SUB Err_check(REAL Addr)
580   Err_check:            ! Just for finding SUB via 'edit err_check'
590     COM /Debug/ INTEGER Err_check
600   !
610     IF NOT Err_check THEN SUBEXIT         ! hurry back
620   !
630     INTEGER Errnum
640     DIM Errstr$[256]  ! maximum length allowed by SCPI standard
```

```
650   !
660   ! First we have to ensure that all commands have been processed
670   ! before we look for errors.
680   ! Let's misuse errnum to read in the *OPC? response.
690     OUTPUT Addr;"*OPC?"
700     ENTER Addr;Errnum
710   !
720   ! now we can look at the status byte.
730   !
740     IF BINAND(SPOLL(Addr),32) THEN
750  ! RQS set - errors in the error queue.
760  ! get them, print them out until error 0 is found.
770  ! print a short error message first
780       PRINT
790       PRINT "Instrument at VXIbus address ";Addr;" reports error(s) :"
800       PRINT
810       LOOP
820         OUTPUT Addr;":SYST:ERR?"
830         ENTER Addr;Errnum,Errstr$
840       EXIT IF Errnum=0
850         PRINT Errnum;Errstr$
860       END LOOP
870  ! now we clear the instrument status bytes/words by issuing
880  ! a *CLS command.
890  ! This is necessary because we did not actually read out
900  ! the standard event status byte, therefore the error bits are
910  ! not cleared.
920       OUTPUT Addr;"*CLS"
930  ! now a program pause.
940  ! this makes it easy to locate the faulty test program line,
950  ! the user should step over the SUBXIT and will recover
960  ! in the line following the Err_check call.
970       PRINT
980       PRINT "Press <Continue> to continue test program."
990       PRINT "Press <Step> to see BASIC line number ";
1000      PRINT "following the call of Err_check."
1010      PAUSE
1020      SUBEXIT
1030    END IF
1040  SUBEND
```

C

Performance tests

Introduction

The performance of the HP E1440A can be tested at three levels:

- **Functional Verification Tests** - These check that the instrument functions are working. Use these tests when you want to check that the module is connected properly and responding to commands from the controller. No access to the interior of the module is necessary.
- **Operational Verification Tests** - These check that the instrument meets critical specifications. Use these tests after a repair, or as an aid to troubleshooting. These tests can be carried out *without* a controller.
- **Performance Verification Tests** - These check that the instrument meets all warranted specifications. Use these tests as an instrument calibration check, after repair or as an aid to troubleshooting.

Note

The HP E1440A specifications, given in Chapter 1, are valid after a 30 minute warm up period.

All test equipment used must also be allowed to warm up before testing the HP E1440A. Refer to the equipment specifications to find the warm up time required.

Test Record

You can record the results of the **Performance Verification Tests** using the Test Record provided at the end of this chapter. You can reproduce this Performance Verification Test Record without written permission from Hewlett-Packard.

Recommended Test Equipment

The equipment required for the tests is listed in Table C-1. Any equipment which satisfies the critical specifications given in the table, may be substituted for recommended models.

Table C-1. Recommended Test Equipment for Tests

Instrument	Critical Specifications	Recommended Model	Test[1]
VXI Mainframe (Development)	Must allow access to the Service switch on top of the HP E1440A.	HP E1400T	O[2]
VXI Mainframe		HP E1400B	F O P
Command Module	HP-IB interface	HP E1405A	F O P
Controller	HP BASIC 5.0/5.1	HP 9000 Series 200/300	F O P
Analog Oscilloscope	Vertical Deflection: 0.01 to 5 V/div Horizontal Sweep:10 ns to 0.5 s/div	HP 1722A/25A	P
Electronic Counter	Frequency measurement Time Interval Average A to B Frequency Range: to 100 MHz Resolution: 11 digits	HP 5370B	O P
AC/DC Digital Voltmeter	AC Function (True RMS) Ranges: 10 mV to 1000 V Bandwidth: 1 Hz to 10 MHz Resolution: 4.5 digits minimum DC Functions Ranges: 10 mV to 1000 V	HP 3458A	P
High-speed Digital Voltmeter	DC Voltage: 0 to ±10 V External Trigger:Low True Trigger Delay:Selectable 1 μs to 10 ms	HP 3437A	P
Frequency Synthesizer Source	Frequency: 20 MHz Amplitude: 10 V(p-p) into 50Ω	HP 3324A/3325B	P
Power Meter	Accuracy: < ±0.5%	HP 436A	P
Power Sensor	50 Ω, 100 mW (24 dBm)	HP 8482A	P
50Ω Feedthru Termination	Accuracy: ±1% Power Rating: 2 W	HP 10100C	P

1 F = Functional, O = Operational, P = Performance

2 Only required if you are testing *without* a controller.

Table C-1. Recommended Test Equipment for Tests (continued)

Instrument	Critical Specifications	Recommended Model	Test[1]
Spectrum Analyzer	Frequency Range: 20 Hz to 40.1 MHz Spurious Responses: 80 dB below reference	HP 3585B	P
Double Balanced Mixer	Impedance: 50Ω Frequency Range: 1 – 20 MHz	HP 10534A	P
1 MHz Low Pass Filter	Cut-off Frequency: 1 MHz Stopband Atten: 50 dB by 4 MHz Stopband Freq: 4 – 80 MHz	Model J903, TTE Inc. 2214 S. Benny Ave. Los Angeles, CA 90064	P
15 kHz Filter	Consisting of: Resistor: 10 KΩ 1% Capacitor: 1600 pF 5%		P
Resistors:	20Ω 1/4 W 1% 30Ω 1/4 W 1% 50Ω 1/8 W 1% 475Ω 2 W 1%		P
Capacitor:	300 pF 5%		P
BNC-to-Triax Cable	Female BNC to Male Triax	HP 1250-0256	P
Adaptors	BNC female to dual banana plug BNC Tee	HP 1251-2277 HP 1250-0781	P P

Functional Verification Tests

The best method of checking that the module is functioning is to:

1. Configure and install the module in a VXI mainframe, as described in Chapter 2.
2. Use the controller to carry out a module self-test and check the results. An example program is given in this section.
3. Check the instrument output with an oscilloscope. An example program is given in this section.

If a controller is not available, carry out the Operational Verification Tests described in the next section. These can be performed with or without a controller, but do not include the instrument self-test.

Note

The HP E1440A has a "Failed" indicator that remains on if the synthesizer is not able to communicate with the controller.

Performing a Self-test

Starting the test

The instrument's self-test routine can be executed by sending it the command: *TST?

Sending the self test command is an easy way to check that you are correctly addressing the synthesizer module, and is also useful in locating intermittent problems which might occur during operation.

The result of the self-test is returned as a number where a value of zero indicates that no errors occurred. If one or more errors occur, they are added to the instrument error queue and a bit is set in the self-test result to indicate the error types:

Table C-2. Self-test result bits

Bit	Meaning	Module
Bit 0 (1)	ROM test failed	A2
Bit 1 (2)	RAM test failed	A2
Bit 2 (4)	Device bus test failed	A2
Bit 3 (8)	Software timer test failed	A2
Bit 4 (16)	Sweep timer test failed	A1
Bit 5 (32)	Amplitude calibration failed	A1 or A2
Bit 6 (64)	Fractional-N IC test failed	A1
Bit 7 (128)	VCO test failed	A1
Bit 8 (256)	Self-test was called when SWEEP or LIST was in progress. No test was carried out.	–

Refer also to the *TST? entry in Chapter 5 Command Reference in the User Manual.

Reading the Error Queue

When errors occur as a result of self-test or during operation, error codes and messages are added to the synthesizer error queue. The error queue can store up to 30 codes and messages on a 'first in first out' (FIFO) basis.

These errors can be read out using the command: SYS:ERR?

A returned value of 0 (zero) means there are no more errors.

Refer to the SYS:ERR? entry in Chapter 5 Command Reference in the User Manual.

Error numbers and messages are listed in Appendix E of the User's Manual.

Example program

The following BASIC 5.0/5.1 program executes a self-test. The program assumes the mainframe is at a primary interface address of 09 and the synthesizer is at a secondary address of 11. The program also assumes that an HP 9000 Series 200/300 computer is used.

```
10  !Send the self-test command to the synthesizer
20  !
30  OUTPUT 70911;"*TST?"
40  !
50  !Enter and display the self test code
60  !
70  ENTER 70911;A
80  PRINT A
90  !
100  !Add code here to interrogate the error queue
110  if A is non-zero.
```

Checking the Instrument Output

After self-test, a simple test with an oscilloscope will check that the module output is functional. Connect an oscilloscope to the output BNC and then send the following short program:

```
10  !Reset the synthesizer
20  !
30  OUTPUT 70911;"*RST"
40  END
50  ! Set frequency value
60  !
70  OUTPUT 70911;":FREQ 1E3"
80  !
90  ! Set function to sinewave
100  OUTPUT 70911;":FUNC SIN"
110  !
120  ! Set output level to 1 V
130  !
140 OUTPUT 70911;":VOLT 1"
150 !
160 Switch on the output
170 !
180 OUTPUT 70911;":OUTP ON"
190 END
```

Operational Verification Tests

Without a Controller

A DIL switch called the **Service Switch**, situated beside the address switch (see Figure C-1 and Figure C-2), can be used to force different startup values for the waveform, frequency and amplitude, as detailed in Table C-3.

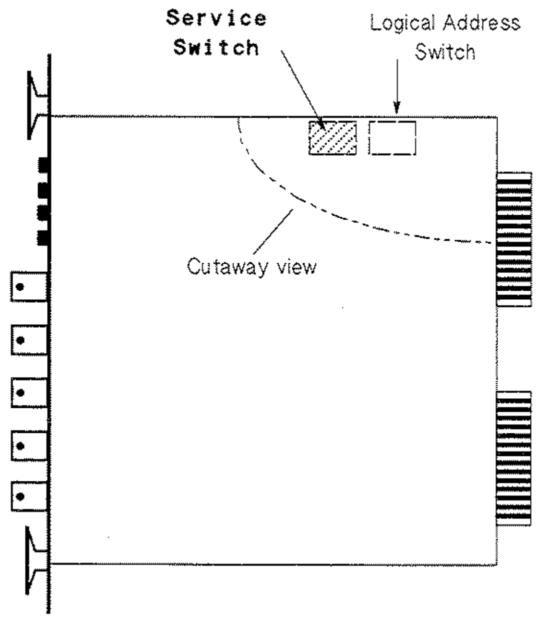

Figure C-1. Service Switch

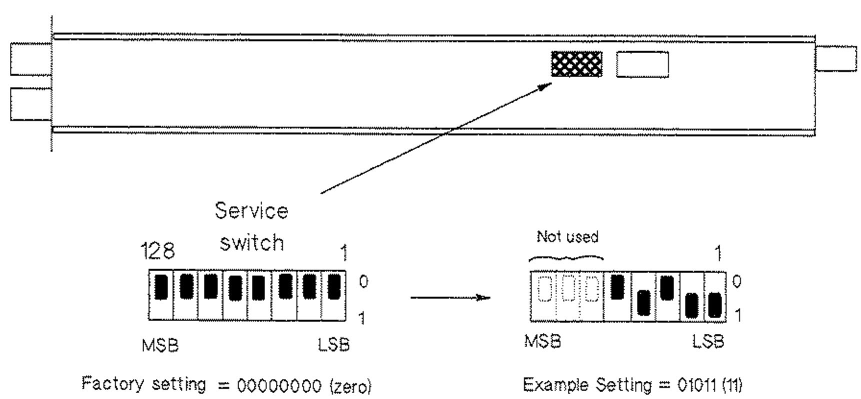

Figure C-2. Example Service Switch Setting

1. Configure and install the module in a VXI mainframe, as described in Chapter 2.
2. For each of the switch settings in Table C-3:
   a. Switch off the mainframe.
   b. Set up the Service Switch.

Caution

If you are not using a Development mainframe, you have to remove the HP E1440A to access the Service Switch. *The mainframe must be switched off when removing or inserting the HP E1440A.*

   c. Switch on the mainframe.
   d. Using a timer and oscilloscope check that the output's frequency and amplitude are as given in Table C-3 and within specification.
3. Set the Service Switch back to 00000.

With a Controller

1. Configure and install the module in a VXI mainframe, as described in Chapter 2.
2. For each of the settings in Table C-3:
   a. Use the controller to set the waveform, frequency and amplitude to the values in the table, for example:

```
OUTPUT 70911; ":FUNC SIN"             Set waveform to sine
OUTPUT 70911; ":FREQ 10 MHZ"          Set frequency to 10 MHz
OUTPUT 70911; ":VOLT:AMPL 10.0 V"     Set amplitude to 10 V
OUTPUT 70911; ":OUTP ON"              Turn on the output
```

   b. Using a timer and oscilloscope check that the output's frequency and amplitude are as given in Table C-3 and within specification.

Table C-3. Service Switch Parameter Settings

Switch	Dec equiv	Waveform	Freq (MHz)	Ampl (V_{pp})	Other
[1]00000	0	sin	0.0	0.001	
00001	1	sin	0.001	10.0	
00010	2	sin	8.0	10.0	
00011	3	sin	10.0	10.0	
00100	4	sin	13.0	10.0	
00101	5	sin	20.0	10.0	
00110	6	sin	21.0	10.0	
00111	7	squ	0.001	10.0	
01000	8	squ	10.0	10.0	
01001	9	squ	11.0	10.0	
01010	10	tri	0.01	10.0	
01011	11	rup	0.01	10.0	
01100	12	ttl	25.0	——	
01101	13	ttl	30.0	——	
01110	14	ttl	35.0	——	
01111	15	ttl	40.0	——	
10000	16	ttl	45.0	——	
10001	17	ttl	50.0	——	
10010	18	ttl	55.0	——	
10011	19	ttl	60.0	——	
10100	20	sin	0.0	10.0	
10101	21	squ	0.0	10.0	
10110	22	tri	0.0	10.0	
10111	23	rup	0.0	10.0	
11000	24	rdow	0.00	10.0	
[2]11001	25	dc	——	——	3V offset

Notes

1 Standard reset values

2 Values over 25 are treated as 25

Performance Verification Tests

Table C-4 groups the Performance Verification Tests according to the warranted specifications in Chapter 1. The tests follow in the order given in the table. All the tests require a controller and a VXI mainframe with the HP E1440A and a command module installed.

Table C-4.

Warranted Specifications (Refer to Chapter 1)	Verification Test(s)
Sinewave Spectral Purity	Harmonic Distortion[1] Spurious Signals Integrated Phase Noise
Frequency	Frequency Accuracy
Phase Offset	Phase Increment Accuracy
Amplitude	Amplitude Accuracy[1]
DC Offset	DC Offset Accuracy[1] DC Offset Accuracy with AC Functions
Triangle/Ramp Characteristics	Triangle Linearity

1 Includes procedure to test High Voltage Output Option 001.

Introduction

Before you start the Performance Verification Tests:

1. Check the HP-IB address of your VXI command module and the secondary address of your HP E1440A module.

   The HP E1440A commands given in the test procedures use the variable **Vxi** to represent the full address of the module. Set this variable to the correct address for your test system.

   For example:

HP-IB interface number:	7
VXI command module address:	16
HP E1440A secondary address:	11

   Set the variable **Vxi**=71611, or replace **Vxi** with the number 71611 every time you use one of the example commands.

2. Reset the HP-IB, HP E1440A and check that you are communicating with the HP E1440A:

   ```
   CLEAR 7
   OUTPUT Vxi;"*RST"
   OUTPUT Vxi;":OUTP ON"
   ```

   The "Output On" LED of the HP E1440A should switch on.

Harmonic Distortion

This procedure tests the harmonic distortion of the HP E1440A sine wave output.

Specifications

Harmonic distortion (relative to fundamental)

Fundamental Frequency	No Harmonic Greater Than
0.1 Hz to 199 kHz	–60 dBc
200 kHz to 1.99 MHz	–40 dBc
2 to 14.9 MHz	–30 dBc
15 to 20 MHz	–25 dBc

Equipment Required

Spectrum Analyzer
50Ω Feedthru Termination
Resistor 475Ω 2W 1%
Resistor 50Ω 1/8W 1%
Capacitor 300 pF 5%

Procedure

1. Set the HP E1440A output as follows:

High-voltage	Output Off
Function	Sine
Frequency	20 MHz
Amplitude	999 mV(p-p)
DC Offset	0 V

```
OUTPUT Vxi;":FUNC SIN;:FREQ 2E7;        Set up parameters
    :VOLT:AMPL 0.999;:VOLT:OFFS 0;"
OUTPUT Vxi;":OUTP ON"                   Switch on the output
```

2. Connect the signal output to the spectrum analyzer 50Ω input.
3. Set the spectrum analyzer controls to display the fundamental and at least four harmonics. Verify that all harmonics are at least 25 dB below the fundamental.
4. Set the HP E1440A to 15 MHz

```
OUTPUT Vxi;":FREQ 1.5E7"
```

and verify that all harmonics are at least 25 dB below the fundamental.

5. Set the HP E1440A to the following frequencies and verify thet the harmonics are below the specified levels.

Frequency	Command String	Max Level
14.9 MHz	":FREQ 1.49E7"	−30 dBc
2 MHz	":FREQ 2E6"	−30 dBc
1.99 MHz	":FREQ 1.99E6"	−40 dBc
200 kHz	":FREQ 2E5"	−40 dBc

6. Set the HP E1440A frequency to 50 kHz and the amplitude to 9.99 mV(p-p).

```
OUTPUT Vxi;":FREQ 5E4;:VOLT:AMPL 9.99MV"
```

7. Set the spectrum analyzer controls to display the fundamental and at least three harmonics. (It may be necessary to decrease the video bandwidth to separate the harmonics from the noise floor.) Verify that all harmonics are at least 60 dB below the fundamental.
8. Set the HP E1440A to the following frequencies and verify that all harmonics are 60 dB below the fundamental.

Frequency	Command String
10 kHz	":FREQ 1E4"
1 kHz	":FREQ 1E3"
100 Hz	":FREQ 1E2"

High-Voltage Output (Option 001)

Continued from the previous procedure.

9. Connect the HP E1440A signal output to the analyzer high-impedance input as shown in Figure C-3.

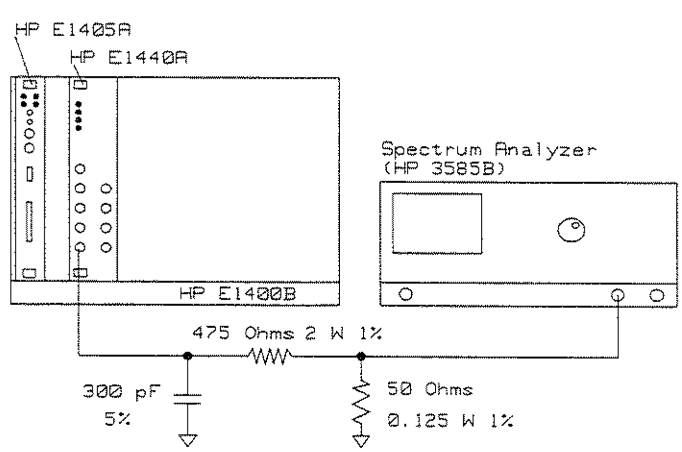

Figure C-3.
Harmonic Distortion Verification Test Set-Up (High-Voltage Output)

10. Select the high-voltage output on the HP E1440A. Set the amplitude to 40 V(p-p) and the frequency to 100 Hz.

```
OUTPUT Vxi;":OUTP:AMPL ON"      Switch on high-voltage output
OUTPUT Vxi;":VOLT:AMPL 40 V"
OUTPUT Vxi;":FREQ 1E2"
```

11. Set the spectrum analyzer controls to display the fundamental and at least three harmonics. Verify that all harmonics are 60 dB below the fundamental.

12. Set the HP E1440A to the following frequencies and verify that the harmonics are below the specified level.

Frequency	Command String	Max Level
10 kHz	":FREQ 1E4"	−60 dBc
100 kHz	":FREQ 1E5"	−60 dBc
200 kHz	":FREQ 2E5"	−40 dBc
1 MHz	":FREQ 1E6"	−40 dBc

13. Turn off the high-voltage output.

```
OUTPUT Vxi;":OUTP:AMPL OFF"
```

Spurious Signal

This procedure tests the HP E1440A sine wave output for spurious signals. Circuits within the HP E1440A may generate repetitive frequencies that are not harmonically related to the fundamental output frequency.

Specifications

All spurious signals must be more than 60 dB below the fundamental signal or less than −85 dBm, whichever is greater.

Equipment Required

Spectrum Analyzer

Mixer Spurious Procedure

1. Connect the HP E1440A signal output to the spectrum analyzer 50Ω (RF) input and the HP E1440A REF INput to the analyzer 10 MHz reference output, as shown in Figure C-4.

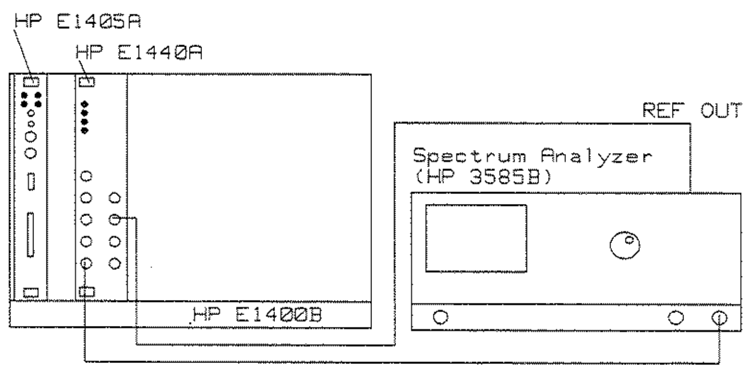

Figure C-4. Mixer Spurious Test Set-Up

2. Set the HP E1440A as follows:

Function	Sine
Frequency	2.001 MHz
Amplitude	63.24 mV(p-p)

```
OUTPUT Vxi;":FUNC SIN;:FREQ 2.001E6;:VOLT:AMPL 63.24MV"
```

3. Set the analyzer controls as follows:

Center Frequency	2.001 MHz
Frequency Span	1 kHz
Video BW	100 Hz
Resolution BW	30 Hz

4. Adjust the spectrum analyzer to reference the fundamental to the top display graticule.

5. Without changing the reference level, change the spectrum analyzer center frequency to 27.999 MHz to display the 2:1

mixer spur. Verify that this spur is at least 60 dB below the fundamental.

6. Change the spectrum analyzer center frequency to 25.998 MHz to display the 3:2 mixer spur. Verify that this spur is at least 60 dB below the fundamental.
7. In the same way, change the HP E1440A frequency and the spectrum analyzer center frequency to the following frequencies. For each setting, verify that all spurious signals are 60 dB below the fundamental.

HP E1440A		Spectrum Analyzer Center Frequency	
Frequency	**Command String**	**2:1 Spur**	**3:2 Spur**
4.100 MHz	":FREQ 4.1E6"	25.9 MHz	21.8 MHz
6.100 MHz	":FREQ 6.1E6"	23.9 MHz	17.8 MHz
8.100 MHz	":FREQ 8.1E6"	21.9 MHz	13.8 MHz
10.100 MHz	":FREQ 10.1E6"	19.9 MHz	9.8 MHz
12.100 MHz	":FREQ 12.1E6"	17.9 MHz	5.8 MHz
14.100 MHz	":FREQ 14.1E6"	15.9 MHz	1.8 MHz
16.100 MHz	":FREQ 16.1E6"	13.9 MHz	2.2 MHz
18.100 MHz	":FREQ 18.1E6"	11.9 MHz	6.2 MHz
20.100 MHz	":FREQ 20.1E6"	9.9 MHz	10.2 MHz

Close-in Spurious (Fractional N Spurs) Procedure

This procedure continues from the previous one.

8. Set the HP E1440A to 5.001 MHz and the amplitude to 448.3 mV(p-p).

```
OUTPUT Vxi;":FREQ 5.001E6;:VOLT:AMPL 448.3MV"
```

9. Set the spectrum analyzer controls as follows:

Center Frequency	5.001 MHz
Frequency Span	1 kHz
Video BW	100 Hz
Resolution BW	30 Hz

10. Adjust the spectrum analyzer to reference the fundamental to the top display graticule.
11. Without changing the reference level, change the spectrum analyzer center frequency to 5.002 MHz to display the API 1 spur. It may be necessary to decrease the video bandwidth to optimize the display resolution.
12. All spurious (non-harmonic) signals should be at least 60 dB below the fundamental.

13. Without changing the reference level, set the HP E1440A frequency and the spectrum analyzer center frequency to the frequencies listed in the following table. For each setting, verify that all spurious signals are at least 60 dB below the fundamental.

HP E1440A		Spectrum Analyzer
Frequency	**Command String**	**Center Frequency**
5.0001 MHz	":FREQ 5.0001E6"	5.0011 MHz
5.00001 MHz	":FREQ 5.00001E6"	5.00101 MHz
5.000001 MHz	":FREQ 5.00001E6"	5.001001 MHz
20.001 MHz	":FREQ 20.001E6"	20.002 MHz
20.001 MHz		20.003 MHz
20.001 MHz		20.004 MHz
20.001 MHz		20.005 MHz

Integrated Phase Noise

This procedure tests the HP E1440A integrated phase noise.

Specifications

−55 dB for a 30 kHz band centered on a 20 MHz carrier (excluding ±1 Hz about the carrier).

Equipment Required

Frequency Synthesizer
Double Balanced Mixer
50Ω Feedthru Termination
AC/DC Digital Voltmeter
15 kHz Noise Equivalent Filter
1 MHz Low Pass Filter

Procedure

1. Connect the equipment as shown in Figure C-5, connecting the output of the 15 kHz noise equivalent filter to the DVM. Phase lock the HP E1440A and the signal generator together.

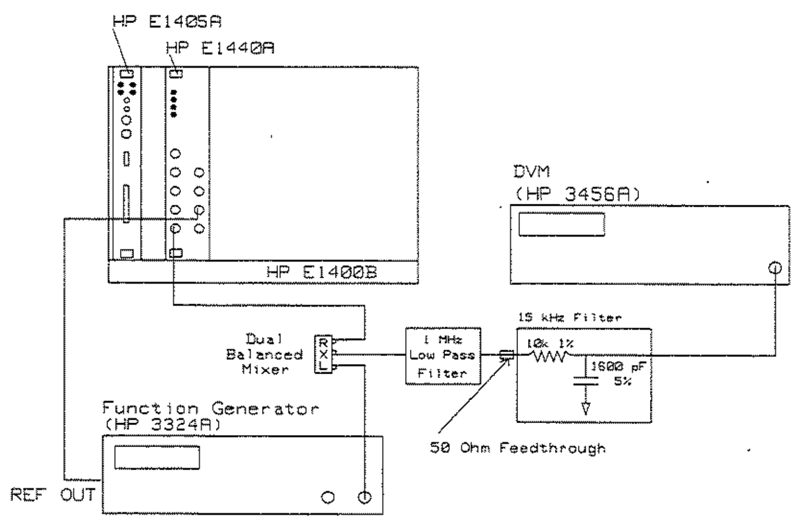

Figure C-5. Integrated Phase Noise Test Set-Up

2. Set the HP E1440A as follows:

Function	Sine
Frequency	19.901 MHz
Amplitude	632 mV(p-p)

```
OUTPUT Vxi;":FUNC SIN;:FREQ 19.901E6;:VOLT:AMPL 632MV"
```

3. Set the synthesizer (reference) as follows:

Frequency	19.9 MHz
Amplitude	1.416 V(p-p)

4. Record the DVM reading as V_{1k}.

5. Change the HP E1440A frequency to 19.9 MHz.

```
OUTPUT Vxi;":FREQ 19.9E6"
```

6. Set the HP E1440A phase reference, and step size to 1 degree.

```
OUTPUT Vxi;":PHAS:REF;STEP 1 DEG"
```

7. Using the following commands as appropriate, adjust the phase for a minimum reading on the DVM.

```
OUTPUT Vxi;":PHAS UP"      Increment phase
OUTPUT Vxi;":PHAS DOWN"    Decrement phase
```

8. Record this minimum reading as V_0.

9. Calculate the dB ratio of V_0 to V_{1k} using the following formula:

$$20 log_{10} \frac{V_0}{V_{1k}}$$

10. Add -6 dB to the ratio to allow for the folding action of the mixer, and record the result on the Performance Test Record. The specification is -55 dB or lower (-54 dB fails).

Note The frequencies used minimize the phase noise contribution of the frequency synthesizer.

Frequency Accuracy

This procedure compares the accuracy of the HP E1440A output signal to the specification.

Specifications

$\pm 5 \times 10^{-6}$ of selected frequency (20°C to 30°C).

Equipment Required

Electronic counter (calibrated within three months or with an accurate 10 MHz external reference input)

Procedure

1. Connect the HP E1440A signal output to the electronic counter channel A input with a 50Ω feedthru termination. Allow the HP E1440A to warm up for 30 minutes and the counter's frequency reference to warm up for its specified period.
2. Set the HP E1440A output as follows:

High-Voltage Output	Off
Function	Sine
Frequency	20 MHz
Amplitude	0.99 V(p-p)
DC Offset	0 V

```
OUTPUT Vxi;":OUTP:AMPL OFF;
      :FUNC SIN;:FREQ 2E7;
      :VOLT:AMPL 0.99;
      :VOLT:OFFS 0"
```

3. Set the counter's gate time to 0.01 s to measure the frequency of the A input with 0.1 Hz resolution. If necessary adjust the trigger level for stable triggering. The electronic counter should indicate 20,000,000.00 Hz ±100 Hz.
4. Change the HP E1440A frequency 10 MHz. Change the function to a square wave. The electronic counter should indicate 10,000,000.00 Hz ±50 Hz.

```
OUTPUT Vxi;":FUNC SQU;:FREQ 1E7"
```

5. Change the HP E1440A frequency 10 kHz. Change the function to a triangle. Set the counter's gate time to 0.1 s. The electronic counter should indicate 100,000.00 ns ±0.5 ns.

```
OUTPUT Vxi;":FREQ 1E4"
```

6. Change the HP E1440A function to a positive slope ramp. The electronic counter should indicate 100,000.00 ns ±0.5 ns.

```
OUTPUT Vxi;":FUNC RUP"
```

Phase Increment Accuracy

This procedure compares the phase increment accuracy of the HP E1440A to the specification.

Specifications

±0.5°

Equipment Required

Frequency Synthesizer
Electronic Counter

Procedure

1. Connect the equipment as shown in Figure C-6.

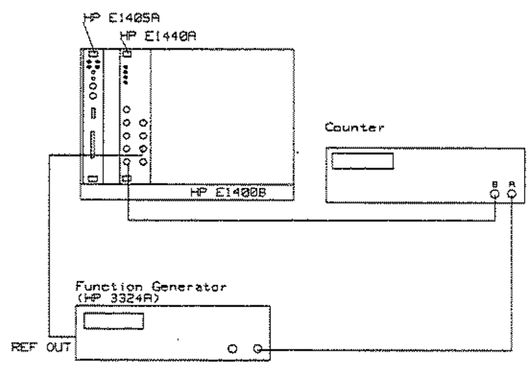

Figure C-6. Phase Increment Accuracy Test Set-Up

2. Set the HP E1440A as follows:

High-Voltage Output	Off
Function	Sine
Frequency	100 kHz
Amplitude	13 dBm

```
OUTPUT Vxi;":OUTP:AMPL OFF"
OUTPUT Vxi;":FUNC SIN;:FREQ 1E5"
OUTPUT Vxi;":VOLT:UNIT DBM;AMPL 13;OFFS 0"
```

3. Set the synthesizer as follows:

Frequency	0.1 MHz
Amplitude	13 dBm

4. Set the counter as follows:

Function	Time Interval
Inputs	50Ω, separate
Slope A and B	Positive
Sample Size	10 k

5. Set the phase units to degrees, and assign current signal phase as the 0° phase reference.

```
OUTPUT Vxi;":PHAS:UNIT DEG"
OUTPUT Vxi;":PHAS:REF"
```

6. Set the counter display rate close to the "hold" position, then reset the counter. Record the counter reading in nanoseconds (to 2 decimal places) on the Performance Test Record in the space for Zero-Phase Time-Reference.
7. Set the HP E1440A phase to −1°.

   ```
   OUTPUT Vxi;":PHAS -1"
   ```

8. Reset the counter. Record the counter reading in nanoseconds (to 2 decimal places) in the space for 1° Increment Time Interval.
9. Determine the time difference between the counter readings ,nd the Zero-Phase Time-Reference and record it in the Time Difference column. This difference reperesents 1° at the test frequency.
10. Set the HP E1440A phase to −10°.

    ```
    OUTPUT Vxi;":PHAS -10"
    ```

11. Reset the counter. Record the counter reading in the space for 10° Increment Time Interval.
12. Enter the time difference between the Zero-Phase Time-Reference and this reading in the Time Difference column. This represents 10° at the test frequency.
13. Set the HP E1440A phase to −100°.

    ```
    OUTPUT Vxi;":PHAS -100"
    ```

14. Reset the counter. Record the counter reading in the space for 100° Increment Time Interval.
15. Enter the time difference between the Zero-Phase Time-Reference and this reading in the Time Difference column. This represents 100° at the test frequency.

Amplitude Accuracy

This procedure tests the amplitude accuracy of the HP E1440A AC-function output signals.

Specifications

See Chapter 1

Equipment Required

AC/DC Digital Voltmeter
High Speed Digital DC Voltmeter
Analog Oscilloscope
50 Ω Feedthru Termination
Power Meter
Power Sensor
Resistor 500 Ω 2 W 1%
Resistor 475 Ω 2 W 1%
Resistor 50 Ω 1/8 W 1%
Capacitor 300 pF 5%

Note

After each new amplitude setting you must perform an amplitude calibration:

```
OUTPUT Vxi;":CAL?"
```

Amplitude Accuracy at Frequencies upto 100 kHz Procedure

1. **Sine wave Test.** Connect the HP E1440A signal output through a 50Ω feedthru termination to the AC digital voltmeter input.
2. Set the HP E1440A as follows:

High-Voltage Output	Off
Function	Sine
Frequency	100 Hz
Amplitude	3.536 Vrms (10 V(p-p))
DC Offset	0 V

```
OUTPUT Vxi;":OUTP:AMPL OFF;
     :FUNC SIN;:FREQ 1E2;
     :VOLT:AMPL 10;
     :VOLT:OFFS 0;
     :CAL?"
```

3. Read the AC voltmeter. Change the HP E1440A frequency to 1 kHz and 100 kHz and repeat.

```
OUTPUT Vxi;":FREQ 1E3"
OUTPUT Vxi;":FREQ 1E5"
```

   Verify that all three voltmeter readings are between 3.455 and 3.617 Vrms (±0.2 dB).

4. Change the HP E1440A amplitude to 1.061 Vrms (3 V(p-p)) and take AC voltage readings for 100 Hz, 1 kHz and 100 kHz as above.

```
OUTPUT Vxi;":VOLT:AMPL 3"

OUTPUT Vxi;":FREQ 1E2"
OUTPUT Vxi;":FREQ 1E3"
OUTPUT Vxi;":FREQ 1E5"
```

Verify that all three voltmeter readings are between 1.037 and 1.085 Vrms (±0.2 dB).

5. Change the HP E1440A amplitude to 0.3536 Vrms (1 V(p-p)) and set the DC offset to 1 mV. Set the HP E1440A frequency to 100 Hz, 1 kHz and 100 kHz, and read the AC voltage.

```
OUTPUT Vxi;":VOLT:AMPL 1;
     OFFS 1MV"

OUTPUT Vxi;":FREQ 1E2"
OUTPUT Vxi;":FREQ 1E3"
OUTPUT Vxi;":FREQ 1E5"
```

Verify that all three readings are between 0.3370 and 0.3702 Vrms (±0.4 dB).

6. **Function Test.** Set up the equipment as shown in Figure C-7.

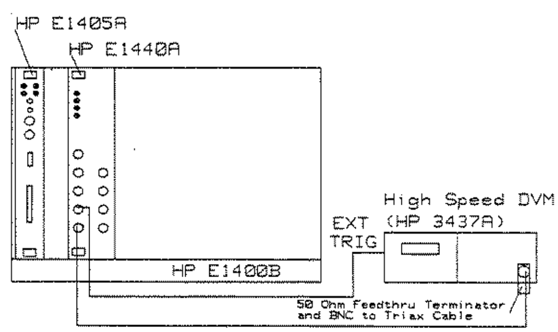

Figure C-7. Function Amplitude Accuracy Test Set-Up

7. Set the HP E1440A as follows:

High-Voltage Option	Off
Function	Square
Frequency	99.9 Hz
Amplitude	10 V(p-p)
DC Offset	0 V

```
OUTPUT Vxi;":OUTP:AMPL OFF;
     :FUNC SQU;:FREQ 9.99E1;
     :VOLT:AMPL 10;
     :VOLT:OFFS 0;
     :CAL?"
```

8. Set the voltmeter as follows:

Range	10 V
Trigger	Ext
Delay	0 s
Coupling	DC, 1 MΩ

9. For all the E1440A frequency and function settings given in the following table:

   a. Set the voltmeter delay to the **Positive Peak** value given in the table and note the positive peak voltage of the waveform on the voltmeter. If the reading is not stable, press "hold" and "ext" alternately to repeat readings.

   b. Set the voltmeter delay to the **Negative Peak** value given in the table and note the negative peak voltage.

   c. Calculate the peak-to-peak voltage from the two readings and record it on the Test Record. This acceptable limits are given here and on the Test Record.

E1440A		**DVM delay (s)**		**Limits (V_{p-p})**	
Frequency	**Function**	**Positive Peak**	**Negative Peak**	**Minimum**	**Maximum**
":FREQ 9.99E1"	":FUNC TRI"	0.0075	0.0125	9.85	10.15
	":FUNC RUP"	0.01	0.00001	9.85	10.15
	":FUNC RDOW"	0.005	0.0149	9.85	10.15
":FREQ 1E3"	":FUNC SQU"	0.00075	0.00125	9.85	10.15
":FREQ 2E3"	":FUNC TRI"	0.000375	0.000625	9.85	10.15
":FREQ 5E2"	":FUNC RUP"	0.0020	0.000012	9.85	10.15
	":FUNC RDOW"	0.001	0.00297	9.85	10.15
":FREQ 1.01E5"	":FUNC SQU"	0.0000075	0.0000125	9.50	10.50
":FREQ 1E4"	":FUNC TRI"	0.000075	0.000125	9.50	10.50
	":FUNC RUP"	0.000098	0.000006	9.00	11.00
	":FUNC RDOW"	0.0000525	0.000146	9.00	11.00

10. Change the HP E1440A amplitude to 3 V(p-p), and perform a calibration.

```
OUTPUT Vxi;":VOLT:AMPL 3;
     :CAL?"
```

11. Repeat steps 9a to 9c for all the E1440A frequency and function settings given in the following table:

E1440A		DVM delay (s)		Limits (V_{p-p})	
Frequency	**Function**	**Positive Peak**	**Negative Peak**	**Minimum**	**Maximum**
":FREQ 9.99E1"	":FUNC SQU"	0.0075	0.0125	2.955	3.045
	":FUNC TRI"	0.0075	0.0125	2.955	3.045
	":FUNC RUP"	0.01	0.00001	2.955	3.045
	":FUNC RDOW"	0.005	0.0149	2.955	3.045
":FREQ 1E3"	":FUNC SQU"	0.00075	0.00125	2.955	3.045
":FREQ 2E3"	":FUNC TRI"	0.000375	0.000625	2.955	3.045
":FREQ 5E2"	":FUNC RUP"	0.0020	0.000012	2.955	3.045
	":FUNC RDOW"	0.001	0.00297	2.955	3.045
":FREQ 1.01E5"	":FUNC SQU"	0.0000075	0.0000125	2.700	3.300
":FREQ 1E4"	":FUNC TRI"	0.000075	0.000125	2.850	3.150
	":FUNC RUP"	0.000098	0.000006	2.700	3.300
	":FUNC RDOW"	0.0000525	0.000146	2.700	3.300

12. Change the HP E1440A amplitude to 1 V(p-p), offset to 1 mV and perform a calibration.

```
OUTPUT Vxi;":VOLT:AMPL 1;
      :VOLT:OFFS 1 MV;
      :CAL?"
```

13. Repeat steps 9a to 9c for all the E1440A frequency and function settings given in the following table:

E1440A		DVM delay (s)		Limits (V_{p-p})	
Frequency	**Function**	**Positive Peak**	**Negative Peak**	**Minimum**	**Maximum**
":FREQ 9.99E1"	":FUNC SQU"	0.0075	0.0125	0.978	1.022
	":FUNC TRI"	0.0075	0.0125	0.973	1.027
	":FUNC RUP"	0.01	0.00001	0.973	1.027
	":FUNC RDOW"	0.005	0.0149	0.973	1.027
":FREQ 1E3"	":FUNC SQU"	0.00075	0.00125	0.978	1.022
":FREQ 2E3"	":FUNC TRI"	0.000375	0.000625	0.973	1.027
":FREQ 5E2"	":FUNC RUP"	0.0020	0.000012	0.973	1.027
	":FUNC RDOW"	0.001	0.00297	0.973	1.027
":FREQ 1.01E5"	":FUNC SQU"	0.0000075	0.0000125	0.900	1.100
":FREQ 1E4"	":FUNC TRI"	0.000075	0.000125	0.938	1.062
	":FUNC RUP"	0.000098	0.000006	0.888	1.112
	":FUNC RDOW"	0.0000525	0.000146	0.888	1.112

High-Voltage Output (Option 001)

Amplitude Accuracy for Frequencies ≤ 100 kHz

This procedure continues from the previous one.

14. **Sine wave Test.** Connect the HP E1440A signal output to the AC voltmeter as shown in Figure C-8.

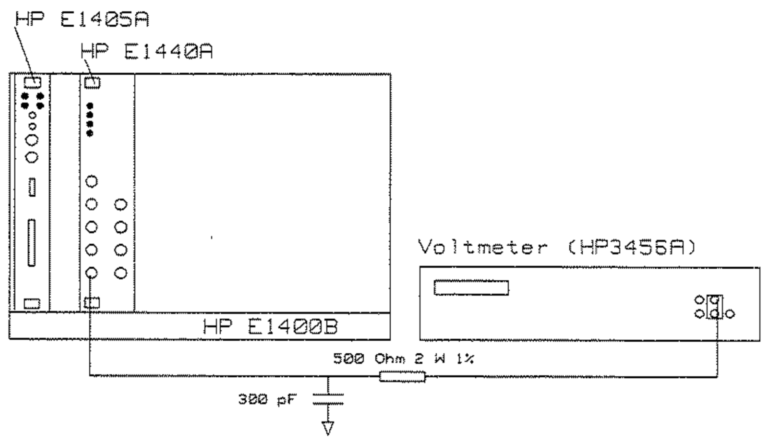

Figure C-8. High voltage sinewave accuracy test set-up.

15. Set up the HP E1440A as follows:

High-Voltage Option	ON
Function	Square
Frequency	2 kHz
Amplitude	40 V(p-p)
DC Offset	0 V

and calibrate.

```
OUTPUT Vxi;":OUTP:AMPL ON;
      :FUNC SIN;:FREQ 2E3;
      :VOLT:AMPL 40;
      :VOLT:OFFS 0;
      :CAL?"
```

16. Record the voltmeter reading on the Test Record. It should lie between 13.86 and 14.42 Vrms.

17. **High-Voltage Function Test.** Connect the equipment as shown in Figure C-9.

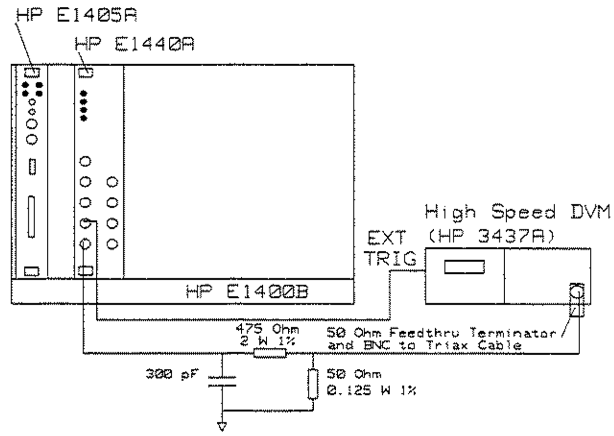

Figure C-9.
Function Amplitude Accuracy Test Set-Up (High-Voltage Output)

18. The voltage divider shown in Figure C-9 is built into a small metal box with 2 BNC connectors. Parts used are:

    R3, 475Ω 2 W 1%
    R4, 50Ω 1/8 W 2%
    C1, 300 pF 5%

19. Set up the HP E1440A as follows:

High-Voltage Option	ON
Function	Square
Frequency	2 kHz
Amplitude	40 V(p-p)
DC Offset	0 V

and calibrate.

```
OUTPUT Vxi;":OUTP:AMPL ON;
     :FUNC SIN;:FREQ 2E3;
     :VOLT:AMPL 40;
     :VOLT:OFFS 0;
     :CAL?"
```

20. For all the E1440A frequency and function settings given in the following table:

   a. Set the voltmeter delay to the **Positive Peak** value given in the table and note the positive peak voltage of the waveform on the voltmeter. If the reading is not stable, press "hold" and "ext" alternately to repeat readings.
   b. Set the voltmeter delay to the **Negative Peak** value given in the table and note the negative peak voltage.
   c. Calculate the peak-to-peak voltage from the two readings and record it on the Test Record. This acceptable limits are given here and on the Test Record.

E1440A		**DVM delay (s)**		**Limits (V_{p-p})**	
Frequency	**Function**	**Positive Peak**	**Negative Peak**	**Minimum**	**Maximum**
":FREQ 2E3"	":FUNC SQU"	0.000375	0.000625	1.96	2.04
	":FUNC TRI"	0.000375	0.000625	1.96	2.04
	":FUNC RUP"	0.000495	0.000508	1.96	2.04
	":FUNC RDOW"	0.000251	0.00074	1.96	2.04

21. Switch off the high-voltage output.

```
OUTPUT Vxi;":OUTP:AMPL OFF;
```

Amplitude Accuracy (Frequencies > 100 kHz)

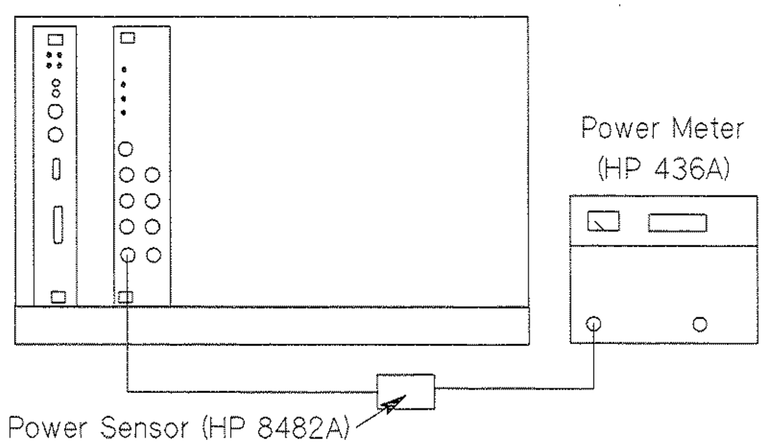

Figure C-10.
Test set-up for Amplitude Accuracy Adjustment (Frequency > 100 kHz)

1. Calibrate the power meter for the sensor using the 50 MHz, 1.00 mW power-reference output on the meter.

2. Set up the HP E1440A as follows:

Function	Sine
Frequency	1 MHz
Amplitude	6 Vp-p (19.54 dBm)
DC Offset	0 V

```
OUTPUT Vxi;" :FUNC SIN;:FREQ 1E6;
      :VOLT:AMPL 6;
      :VOLT:OFFS 0;
      :OUTP ON"
```

3. Connect the output of the HP E1440A to the power meter via the power sensor, as shown in Figure C-10.

4. Switch the power meter to read dBm.

5. Check that the indicated power level is 19.54 dBm ±0.4 dB.

6. For the following frequency settings, check that the indicated power level is 19.54 dBm ±0.4 dB.

   ":FREQ 5E6"
   ":FREQ 1E7"
   ":FREQ 1.5E7"
   ":FREQ 2E7"

7. Set the HP E1440A output amplitude to 2 V (10 dBm).

```
OUTPUT Vxi;":VOLT:AMPL 2"
```

8. For the following frequency settings, check that the indicated power level is 10 dBm ±0.6 dB.

   ":FREQ 1E6"
   ":FREQ 5E6"
   ":FREQ 1E7"
   ":FREQ 1.5E7"
   ":FREQ 2E7"

9. **Square wave accuracy**. Set the HP E1440A as follows:

High-Voltage Output	Off
Function	Square
Frequency	1 kHz
Amplitude	10 V(p-p)
DC Offset	0 V

```
OUTPUT Vxi;":OUTP:AMPL OFF;
      :FUNC SQU;:FREQ 1E3;
      :VOLT:AMPL 10;
      :VOLT:OFFS 0;
```

10. Connect the HP E1440A signal output to an analog oscilloscope using a 50Ω feedthru termination. Set the oscilloscope as follows:

Vertical Sensitivity	2 V/div
Time/div	0.1 ms

11. For each of the following frequency settings from 1 kHz to 10 MHz, verify that the two lines on the oscilloscope are 5 ±0.25 major divisions apart.

    ":FREQ 1E3"
    ":FREQ 2E6"
    ":FREQ 4E6"
    ":FREQ 6E6"
    ":FREQ 1E7"

High-Voltage Output (Option 001)

Amplitude Flatness above 100 kHz

This procedure continues from the previous one.

12. Connect the HP E1440A output to the analog oscilloscope via a 500Ω, 300pF load/voltage divider, as shown in Figure C-11.

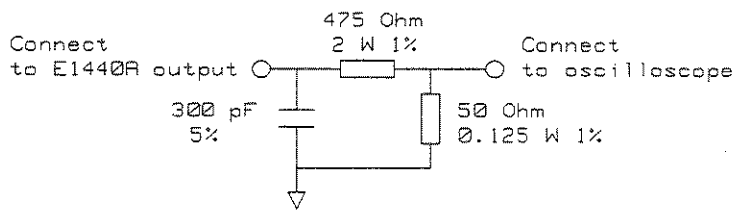

Figure C-11. 500 Ω 300 pF load/Voltage divider

The cable capacitance (30 pF/foot) must be included in the 300 pF.

13. Set the oscilloscope as follows:

Vertical Sensitivity	1 V/div
Time/div	1 ms
Input Impedance	High

14. Set the HP E1440A to 40 V(p-p) sine wave and 1 kHz and adjust the oscilloscope intensity and focus for a sharp trace.

```
OUTPUT Vxi;":OUTP:AMPL ON;
      :FUNC SIN;:FREQ 1E3;
      :VOLT:AMPL 40;
      :VOLT:OFFS 0"
```

15. For each of the following frequency settings from 1 kHz to 1 MHz, verify that the two lines on the oscilloscope are 4 ±0.4 major divisions apart.

    ":FREQ 1E3"
    ":FREQ 2E5"
    ":FREQ 4E5"
    ":FREQ 6E5"
    ":FREQ 8E5"
    ":FREQ 1E6"

16. Switch off the high voltage output.

```
OUTPUT Vxi;":OUTP:AMPL OFF"
```

DC Offset Accuracy (DC only)

This procedure tests the HP E1440A DC offset accuracy when no AC function output is present.

Specifications

1% of full range ±0.02 mV

Equipment Required

DC Digital Voltmeter
50Ω Feedthru Termination

Procedure

1. Connect the HP E1440A signal output directly to the 50Ω feedthru termination and then with a cable to the DC digital voltmeter input.
2. Set the output so that only the DC output is present.

```
OUTPUT Vxi;":FUNC DC"
```

3. Set the HP E1440A DC offset to 5 V, and calibrate.

```
OUTPUT Vxi;":VOLT:OFFS 5;
      :CAL?"
```

4. The voltmeter reading should be between +4.950 and +5.050 V.
5. Change the HP E1440A DC offset to −5 V.

```
OUTPUT Vxi;":VOLT:OFFS -5;
```

6. The voltmeter reading should be between −4.950 and −5.050 V.

Attenuator Test. This procedure continues from the previous one.

7. Set the DC offset to the positive and negative voltages below. The digital voltmeter reading should be within the tolerances shown for each voltage.

DC Offset	Tolerances
":VOLT:OFFS 1.499"	1.48399 to 1.51401 V
":VOLT:OFFS -1.499"	-1.48399 to -1.51401 V
":VOLT:OFFS 499.9 MV"	0.48488 to 0.50491 V
":VOLT:OFFS -499.9 MV"	-0.48488 to -0.50491 V
":VOLT:OFFS 149.9 MV"	0.14838 to 0.15142 V
":VOLT:OFFS -149.9 MV"	-0.14838 to -0.15142 V
":VOLT:OFFS 49.99 MV"	0.04947 to 0.05051 V
":VOLT:OFFS -49.99 MV"	-0.04947 to -0.05051 V
":VOLT:OFFS 14.99 MV"	0.01482 to 0.01516 V
":VOLT:OFFS -14.99 MV"	-0.01482 to -0.01516 V
":VOLT:OFFS 4.999 MV"	0.004929 to 0.005069 V
":VOLT:OFFS -4.999 MV"	-0.004929 to -0.005069 V
":VOLT:OFFS 1.499 MV"	0.001464 to 0.001534 V
":VOLT:OFFS -1.499 MV"	-0.001464 to -0.001534 V

High-Voltage Output (Option 001)

This procedure continues from the previous one.

8. Remove the 50Ω feedthru termination and connect the HP E1440A output directly to the voltmeter input.
9. Select the high-voltage output on the HP E1440A.

```
OUTPUT Vxi;":OUTP:AMPL ON"
```

10. Set the HP E1440A DC offset to 20 V.

```
OUTPUT Vxi;":VOLT:OFFS 20"
```

11. The voltmeter reading should be +19.775 to 20.225 V.
12. Switch off the high voltage output.

```
OUTPUT Vxi;":OUTP:AMPL OFF"
```

DC Offset Accuracy with AC Functions

This procedure tests the HP E1440A DC offset accuracy when an AC function output is present.

Specifications

DC + AC, up to 1 MHz: 1.2%
For ramps up to 10 kHz: 2.4%
DC + AC, from 1 MHz to 20 MHz: 3%

Equipment Required

DC Digital Voltmeter
50Ω Feedthru Termination

Procedure

1. Connect the equipment as shown in Figure C-12, and set the voltmeter to measure DC voltage.

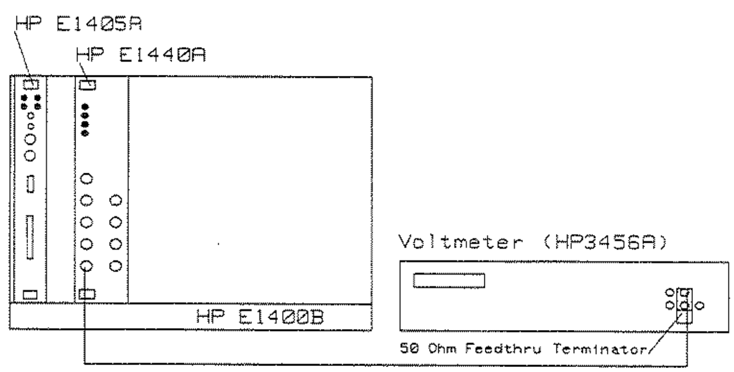

Figure C-12. DC Offset Test Set-Up

2. Set the HP E1440A output as follows, and calibrate:

High-Voltage Output	Off
Function	Sine
Frequency	21 MHz
Amplitude	1 V(p-p)
DC Offset	+4.5 V

```
OUTPUT Vxi;":OUTP:AMPL OFF;
      :FUNC SIN;:FREQ 2.1E7;
      :VOLT:AMPL 1;
      :VOLT:OFFS 4.5;
      :CAL?"
```

3. After amplitude calibration (approximately 2 seconds) the voltmeter reading should be +4.350 to +4.650 Vdc.

4. Change the HP E1440A DC offset to −4.5 V.

```
OUTPUT Vxi;":VOLT:OFFS -4.5"
```

5. The voltmeter reading should be −4.350 to −4.650 Vdc.

6. Change the HP E1440A frequency to 999.9 kHz.

```
OUTPUT Vxi;":FREQ 9.999E5"
```

7. The voltmeter reading should be −4.440 to −4.560 Vdc.
8. Change the HP E1440A DC offset to +4.5 V.

```
OUTPUT Vxi;":VOLT:OFFS 4.5"
```

9. The voltmeter reading should be +4.440 to +4.560 Vdc.
10. Set the HP E1440A function to square.

```
OUTPUT Vxi;":FUNC SQU"
```

11. The voltmeter reading should be +4.440 to +4.560 Vdc.
12. Change the HP E1440A DC offset to −4.5 V.

```
OUTPUT Vxi;":VOLT:OFFS -4.5"
```

13. The voltmeter reading should be −4.440 to −4.560 Vdc.
14. Change the HP E1440A frequency to 9.9999 MHz.

```
OUTPUT Vxi;":FREQ 9.9999E6"
```

15. The voltmeter reading should be −4.350 to −4.650 Vdc.
16. Set the HP E1440A function to triangle, and frequency to 9.9 kHz.

```
OUTPUT Vxi;":FUNC TRI;
            :FREQ 9.9E3"
```

17. The voltmeter reading should be −4.440 to −4.560 Vdc.
18. Set the HP E1440A function to positive ramp.

```
OUTPUT Vxi;":FUNC RUP"
```

The voltmeter reading should be −4.380 to −4.620 V.

Triangle Linearity

This procedure tests the linearity of the HP E1440A triangle wave output. As the triangle and ramp outputs are generated by the same circuits, this procedure also tests the ramp linearity.

Specifications

±0.05% of full output, 10% to 90%, best fit straight line

Equipment Required

High-speed DC Digital Voltmeter
Resistor, 20Ω 1/4 W 1%
Resistor, 30Ω 1/4 W 1%
BNC-to-Triax Adapter

Procedure

1. Connect the HP E1440A and the high-speed voltmeter through the divider as shown in Figure C-13.

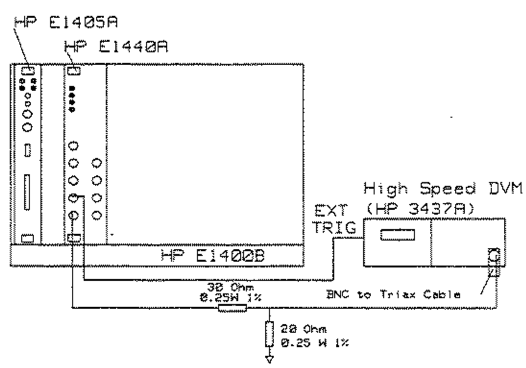

Figure C-13. Triangle Linearity Test Set-Up

2. Set the HP E1440A output as follows:

High-Voltage Output	Off
Function	Triangle
Frequency	10 kHz
Amplitude	10 V(p-p)
DC Offset	0 V

```
OUTPUT Vxi;":OUTP:AMPL OFF;
     :FUNC TRI;:FREQ 1E4;
     :VOLT:AMPL 10;
     :VOLT:OFFS 0"
```

3. Set the voltmeter as follows:

Range	1 V
Number of readings	1
Trigger	External

Note The HP 3437A triggers on the negative going edge of the HP E1440A sync square wave.

4. Set the voltmeter delay to 0.00003 (seconds). Record the voltmeter reading on the Performance Test Record under *Positive Slope Measurement, (10%)y_1*. This is the 10% point on the positive slope of the triangle.
5. Measure the voltage at each 10% segment point by setting the voltmeter delay to the following. Enter on the Performance Test Record in the appropriate spaces under *Positive Slope Measurement*.

Delay	Percent of Slope
0.000035	20
0.00004	30
0.000045	40
0.00005	50
0.000055	60
0.00006	70
0.000065	80
0.00007	90

6. Algebraically add the voltages recorded in the *Positive Slope Measurement* column and enter the total in the $\sum$y space.
7. Measure the voltage at each 10% segment point on the negative slope by setting the voltmeter delay to the following. Enter on the Performance Test Record in the appropriate spaces under *Negative Slope Measurement*.

Delay	Percent of Slope
0.00008	90
0.000085	80
0.00009	70
0.000095	60
0.0001	50
0.000105	40
0.00011	30
0.000115	20
0.00012	10

8. Algebraically add the voltages recorded in the *Negative Slope Measurement* column and enter the total in the $\sum$y space.
9. For the *Positive Slope Measurement* results, multiply Σy by 45 (which is Σx) and enter the result in theΣ xΣy space.

10. Multiply each y value by the corresponding x value and enter in the x times y column. Total these values and enter in the Σxy space.

11. The equation for determining the best fit straight line specification for each y-value is:

$$y' = a_1 x + a_0$$

where a_1 and a_0 are constants to be calculated from the data taken previously.

Note Calculate the values of a_1 and a_0 to at least five decimal places.

---

12. First determine the value of a_1 using the following equation:

$$a_1 = \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}$$

where Σx, Σy, Σxy, $\Sigma x \Sigma y$, Σx^2 , and $(\Sigma x)^2$, are the previously calculated values entered on the Performance Test Record.

where n=9 (the number of points to be calculated).

13. Determine the value of a_0 using the equation:

$$a_0 = \frac{\Sigma y}{n} - \frac{a_1 \Sigma x}{n}$$

14. Calculate the best-fit straight line y' value for each point (y_1 through y_9) using the equation:

$$y' = a_1 x + a_0$$

Enter each result on the Performance Test Record in the *Best-Fit Straight Line* column.

15. For each delay (x), subtract the calculated voltage (y') from the measured voltage (y). Find the largest positive voltage difference ($+V_{max}$) and the largest negative difference ($-V_{max}$). Using the following formula, compute the % linearity.

% linearity = $((|+V_{max}| + |-V_{max}|) \div 8 \text{ volts}) \times 100\%$

16. Add the voltages recorded in the Negative Slope Measurement column algebraically and enter the total in the Σy space.

17. Repeat steps 8 through 14 to determine the best fit straight line values and linearity for the negative slope.

Serial No: __________________________ Report No: _________________________ Date: ___________

Test Facility :

Test Conditions :

Installed Options : ________________________________

Ambient Temperature : ________________________________°C

Relative Humidity : ________________________________%

Line Frequency : ________________________________Hz

Special Notes :

Serial No: ____________________ Report No: ____________________ Date: __________

Test Equipment Used :

Description	Model No.	Serial No.	Trace No.	Cal.Due Date
Digital Oscilloscope				
Counter				
Digital Voltmeter				
Spectrum Analyzer				
AC Voltmeter				
Frequency Synthesizer				
High-speed DC Voltmeter				
Power Meter				
Power Sensor				
Controller				
Command Module				
VXI Mainframe				

Serial No: ____________________________ Report No: ___________________________ Date: ___________

Harmonic Distortion

Harmonic Distortion Test Pass ▢ Fail ▢

Fundamental Frequency		Specification
20 MHz	____________________________	−25 dB
15 MHz	____________________________	−25 dB
14.9 MHz	____________________________	−30 dB
2 MHz	____________________________	−30 dB
1.99 MHz	____________________________	−40 dB
200 kHz	____________________________	−40 dB
50 kHz	____________________________	−60 dB
10 kHz	____________________________	−60 dB
1 kHz	____________________________	−60 dB
100 Hz	____________________________	−60 dB

High-Voltage Output (Option 001)

100 Hz	____________________________	−60 dB
1 kHz	____________________________	−60 dB
10 kHz	____________________________	−60 dB
200 kHz	____________________________	−40 dB
1 MHz	____________________________	−40 dB

Serial No: ______________________ **Report No:** ______________________ **Date:** __________

Spurious Signals

Spurious Signal Test Pass ☐ Fail ☐

Mixer Spurious

	2:1 spur	3:2 spur	Specification
2.001 MHz	________	________	−60 dBc
4.100 MHz	________	________	−60 dBc
6.100 MHz	________	________	−60 dBc
8.100 MHz	________	________	−60 dBc
10.100 MHz	________	________	−60 dBc
12.100 MHz	________	________	−60 dBc
14.100 MHz	________	________	−60 dBc
16.100 MHz	________	________	−60 dBc
18.100 MHz	________	________	−60 dBc
20.100 MHz	________	________	−60 dBc

Close-in-Spurious

5.001 MHz	________________	−60 dBc
5.0001 MHz	________________	−60 dBc
5.00001 MHz	________________	−60 dBc
5.000001 MHz	________________	−60 dBc
20.001 MHz	________________	−60 dBc
20.001 MHz	________________	−60 dBc
20.001 MHz	________________	−60 dBc
20.001 MHz	________________	−60 dBc

Serial No: ______________________ Report No: ______________________ Date: __________

Integrated Phase Noise

Integrated Phase Noise Test Pass ☐ Fail ☐

1st voltmeter reading V_{1k}	______________________	V
2nd voltmeter reading V_0	______________________	V
$20log_{10}\frac{V_0}{V_{1k}}$	= ______________________	dB
		Specification
Result − 6 dB	= ______________________	−55 dB

Frequency Accuracy

Frequency Accuracy Test Pass ☐ Fail ☐

Sine, 20 MHz	______________________	±100 Hz
Square, 10 MHz	______________________	±50 Hz
Triangle, 10 kHz (100,000 ns)	______________________	±0.5 ns
Ramp, 10 kHz (100,000 ns)	______________________	±0.5 ns

Phase Increment Accuracy

Phase Increment Accuracy Test Pass ☐ Fail ☐

	Measured	Minimum	Time Difference	Maximum
Zero-Phase Time-Reference	__________			
1° Increment Time Interval	__________	13.89 ns	__________	41.67 ns
10° Increment Time Interval	__________	263.89 ns	__________	291.67 ns
100° Increment Time Interval	__________	2763.89 ns	__________	2791.67 ns

Amplitude Accuracy

Amplitude Accuracy Test Pass ▢ Fail ▢

Sine wave Test	Minimum	Measured	Maximum
Amplitude: 3.536 Vrms			
Sine, 100 Hz:	3.455 V	______________	3.617 V
Sine, 1 kHz:	3.455 V	______________	3.617 V
Sine, 100 kHz:	3.455 V	______________	3.617 V
Amplitude: 1.061 Vrms			
Sine, 100 Hz:	1.037 V	______________	1.085 V
Sine, 1 kHz:	1.037 V	______________	1.085 V
Sine, 100 kHz:	1.037 V	______________	1.085 V
Amplitude: 0.3536 Vrms			
DC, 1 mV			
Sine, 100 Hz:	0.3370 V	______________	0.3702 V
Sine, 1 kHz:	0.3370 V	______________	0.3702 V
Sine, 100 kHz:	0.3370 V	______________	0.3702 V

Amplitude Accuracy Test (continued)

Function Test	Minimum	Measured	Maximum
Amplitude: 10 V(p-p)			
Square, 99.9 Hz	9.95 V	______________	10.15 V
Triangle, 99.9 Hz	9.85 V	______________	10.15 V
Pos. Ramp, 99.9 Hz	9.85 V	______________	10.15 V
Neg. Ramp, 99.9 Hz	9.85 V	______________	10.15 V
Square, 1 kHz	9.95 V	______________	10.15 V
Triangle, 2 kHz	9.85 V	______________	10.15 V
Pos. Ramp, 500 Hz	9.85 V	______________	10.15 V
Neg. Ramp, 500 Hz	9.85 V	______________	10.15 V
Square, 101 kHz	9.50 V	______________	10.50 V
Triangle, 10 kHz	9.50 V	______________	10.50 V
Pos. Ramp, 10 kHz	9.00 V	______________	11.00 V
Neg. Ramp, 10 kHz	9.00 V	______________	11.00 V
Amplitude: 3 V(p-p)			
Square, 99.9 Hz	2.955 V	______________	3.045 V
Triangle, 99.9 Hz	2.955 V	______________	3.045 V
Pos. Ramp, 99.9 Hz	2.955 V	______________	3.045 V
Neg. Ramp, 99.9 Hz	2.955 V	______________	3.045 V
Square, 1 kHz	2.955 V	______________	3.045 V
Triangle, 2 kHz	2.955 V	______________	3.045 V
Pos. Ramp, 500 Hz	2.955 V	______________	3.045 V
Neg. Ramp, 500 Hz	2.955 V	______________	3.045 V
Square, 101 kHz	2.700 V	______________	3.300 V
Triangle, 10 kHz	2.850 V	______________	3.150 V
Pos. Ramp, 10 kHz	2.700 V	______________	3.300 V
Neg. Ramp, 10 kHz	2.700 V	______________	3.300 V

Serial No: ______________ Report No: ______________ Date: ________

Amplitude Accuracy Test (continued)

Function Test	Minimum	Measured	Maximum
Amplitude: 1 V(p-p)			
DC: 1 mV			
Square, 99.9 Hz	0.978 V	________	1.022 V
Triangle, 99.9 Hz	0.973 V	________	1.027 V
Pos. Ramp, 99.9 Hz	0.973 V	________	1.027 V
Neg. Ramp, 99.9 Hz	0.973 V	________	1.027 V
Square, 1 kHz	0.978 V	________	1.022 V
Triangle, 2 kHz	0.973 V	________	1.027 V
Pos. Ramp, 500 Hz	0.973 V	________	1.027 V
Neg. Ramp, 500 Hz	0.973 V	________	1.027 V
Square, 101 kHz	0.900 V	________	1.100 V
Triangle, 10 kHz	0.938 V	________	1.062 V
Pos. Ramp, 10 kHz	0.888 V	________	1.112 V
Neg. Ramp, 10 kHz	0.888 V	________	1.112 V

High-Voltage Output (Option 001)

Sine wave Test	Minimum	Measured	Maximum
Amplitude: 14.14 Vrms			
Sine, 2 kHz	13.86 V	________	14.42 V

Function Test	Minimum	Measured	Maximum
Amplitude: 40 V(p-p)			
Square, 2 kHz	1.96 V	________	2.04 V
Triangle, 2 kHz	1.96 V	________	2.04 V
Pos. Ramp, 2 kHz	1.96 V	________	2.04 V
Neg. Ramp, 2 kHz	1.96 V	________	2.04 V

Amplitude Accuracy Test (> 100 kHz)	Minimum	MEASURED	Maximum
Sine, 19.54 dBm, 1 MHz	19.14 dBm	________	19.94 dBm
5 MHz	19.14 dBm	________	19.94 dBm
10 MHz	19.14 dBm	________	19.94 dBm
15 MHz	19.14 dBm	________	19.94 dBm
20 MHz	19.14 dBm	________	19.94 dBm
Sine, 10 dBm, 1 MHz	9.4 dBm		10.6 dBm
5 MHz	9.4 dBm	________	10.6 dBm
10 MHz	9.4 dBm	________	10.6 dBm
15 MHz	9.4 dBm	________	10.6 dBm
20 MHz	9.4 dBm	________	10.6 dBm

Square, 10 V(p-p)	Pass ☐		Fail ☐

High-Voltage Output (Option 001)

Sine, 40 V(p-p)	Pass ☐		Fail ☐

Serial No: ________________ Report No: ________________ Date: __________

DC Offset Accuracy (DC only)

DC Offset Accuracy Test (DC Only) Pass ▢ Fail ▢

	Minimum	Measured	Maximum
5 V	+4.950 V	________	+5.050 V
−5 V	−4.950 V	________	−5.050 V
1.499 V	+1.48399 V	________	+1.51401 V
−1.499 V	−1.48399 V	________	−1.51401 V
499.9 mV	+0.49488 V	________	+0.50491 V
−499.9 mV	−0.49488 V	________	−0.50491 V
149.9 mV	+0.14838 V	________	+0.15142 V
−149.9 mV	−0.14838 V	________	−0.15142 V
49.99 mV	+0.04947 V	________	+0.05051 V
−49.99 mV	−0.04947 V	________	−0.05051 V
14.99 mV	+0.01482 V	________	+0.01516 V
−14.99 mV	−0.01482 V	________	−0.01516 V
4.999 mV	+0.004929 V	________	+0.005069 V
−4.999 mV	−0.004929 V	________	−0.005069 V
1.499 mV	+0.001464 V	________	+0.001534 V
−1.499 mV	−0.001464 V	________	−0.001534 V

High-Voltage Output (Option 001)

	Minimum	Measured	Maximum
20 V	+19.775 V	________	+20.225 V
−20 V	−19.775 V	________	−20.225 V

Serial No: ________________________ Report No: ________________________ Date: __________

DC Offset Accuracy with AC Function

DC Offset Accuracy Test with AC Functions

Pass ☐ Fail ☐

	Minimum	Measured	Maximum
Sine, 21 MHz			
4.5 V	+4.350 V	________________	+4.650 V
−4.5 V	−4.350 V	________________	−4.650 V
Sine, 999.9 kHz			
4.5 V	+4.440 V	________________	+4.560 V
−4.5 V	−4.440 V	________________	−4.560 V
Square, 999.9 kHz			
4.5 V	+4.440 V	________________	+4.560 V
−4.5 V	−4.440 V	________________	−4.560 V
Square, 9.9999 MHz			
−4.5 V	−4.350 V	________________	−4.650 V
Triangle, 9.9 kHz			
−4.5 V	−4.440 V	________________	−4.560 V
Ramp, 9.9 kHz			
−4.5 V	−4.380 V	________________	−4.620 V

Triangle Linearity

Triangle Linearity Test (Positive Slope) Pass ☐ Fail ☐

x Values	Positive Slope Measurement y	x times y	Calculated Best-fit Straight Line y'	Difference y - y'
$x_1 = 1$	(10%) y_1_______	_________	(y'_1)__________	__________
$x_2 = 2$	(20%) y_2_______	_________	(y'_2)__________	__________
$x_3 = 3$	(30%) y_3_______	_________	(y'_3)__________	__________
$x_4 = 4$	(40%) y_4_______	_________	(y'_4)__________	__________
$x_5 = 5$	(50%) y_5_______	_________	(y'_5)__________	__________
$x_6 = 6$	(60%) y_6_______	_________	(y'_6)__________	__________
$x_7 = 7$	(70%) y_7_______	_________	(y'_7)__________	__________
$x_8 = 8$	(80%) y_8_______	_________	(y'_8)__________	__________
$x_9 = 9$	(90%) y_9_______	_________	(y'_9)__________	__________
$\Sigma x = 45$	Σy____________	Σxy______		$+V_{max}$____________
$(\Sigma x)^2 = 2025$	$\Sigma x \Sigma y$__________			$-V_{max}$____________
$\Sigma x^2 = 285$				

% Linearity (Positive Slope): ________________

Triangle Linearity Test (Negative Slope) Pass ☐ Fail ☐

x Values	Negative Slope Measurement y	x times y	Calculated Best-fit Straight Line y'	Difference y - y'
$x_1 = 1$	(10%) y_1_______	_________	(y'_1)__________	__________
$x_2 = 2$	(20%) y_2_______	_________	(y'_2)__________	__________
$x_3 = 3$	(30%) y_3_______	_________	(y'_3)__________	__________
$x_4 = 4$	(40%) y_4_______	_________	(y'_4)__________	__________
$x_5 = 5$	(50%) y_5_______	_________	(y'_5)__________	__________
$x_6 = 6$	(60%) y_6_______	_________	(y'_6)__________	__________
$x_7 = 7$	(70%) y_7_______	_________	(y'_7)__________	__________
$x_8 = 8$	(80%) y_8_______	_________	(y'_8)__________	__________
$x_9 = 9$	(90%) y_9_______	_________	(y'_9)__________	__________
$\Sigma x = 45$	Σy____________	Σxy______		$+V_{max}$____________
$(\Sigma x)^2 = 2025$	$\Sigma x \Sigma y$__________			$-V_{max}$____________
$\Sigma x^2 = 285$				

% Linearity (Negative Slope): ________________

D

Command Quick Reference

Introduction

The two tables below, summarize the commands available for the HP E1440A. The commands are fully described in Chapter 5 *Command Reference*. Sample programs may be found in chapters 3 and 4.

SCPI Command Quick Reference

Command	Sub-command & Parameter	Description
:ABORt		Aborts current sweep
:CALibration	[:ALL]?	Checks instrument calibration
:INITiate	:CONTinuous ON|OFF	Enables/disables continuous sweeps
	[:IMMediate]	Starts a sweep cycle
:OUTPut	[:STATe] ON|OFF	Switches/disconnects signal at output connector
	:AMPLify	Specifies the High-voltage Amplifier(Opt 001)
	[:STATe] ON|OFF	Switches High-voltage Amplifier on or off
	:TTLTrg <n>	Controls TTL trigger line outputs
	:SOURce	Selects source for TTL trigger
	:AOFF	Switches off all trigger lines
[:SOURce]	:VOLTage|:POWer|CURRent	
	[:LEVel]	
	[:IMMediate]	
	[:AMPLitude]	Sets amplitude of unswept signal
	:OFFSet	Specifies signal offset
	:UNIT V|DBM|VRMS	Defines unit of amplitude
[:SOURce]	:AM	Specifies Amplitude Modulated signal
	:STATe ON|OFF	AM Signal enabled or disabled
[:SOURce]	:FREQuency [:CW|:FIXed]	Defines signal frequency characteristics, constant wave or fixed
	:MODE CW|FIXed|SWEep|LIST	Determine which **SET** of frequency commands
	:STARt	Specifies sweep start frequency
	:STOP	Specifies sweep stop frequency
	:CENTer	Specifies sweep center frequency
	:SPAN	Specifies overall frequency span
	:HOLD	Maintains span frequency as set
	:LINK CENTer|STARt|STOP	Links span to start, stop or center frequency
	:FULL	Specifies sweep equal to full range of instrument
[:SOURce]	:FUNCtion	Controls shape and attributes of output signal
	[:SHAPe] DC|SINusoidal|SQUare	
	|TRIangle|RUP|RDOWn|TTL	Specify shape of output waveform

SCPI Command Quick Reference (continued)

Command	Sub-command & Parameter	Description
[:SOURce]	:LIST	Output signal sweeps to a set of accompanying lists
	:FREQUENCY	Specifies frequency points for list
	:STARt <num>[,<num>]..	List of sweep start frequencies
	:POINts?	Returns no. of entries in start list
	:STOP	List of sweep stop frequencies
	:POINts?	Returns no. of entries in stop list
	:MARKer	List of sweep markers
	:POINts?	Returns no. of markers in list
	:STATe	Sets markers on/off
	:POINts?	Returns no. of entries in state list
	:SPACing	List of sweep type, linear or logarithmic
	:POINts?	Returns no. of entries in spacing list
	:DWELl	Specifies dwell time occurances for lists
	:POINts?	Returns no. of entries in dwell list
	:SEQuence	Defines a sequence for stepping through a list
	:POINts?	Returns no. of entries in sequence list
	:LENGth?	Returns no. of entries in sweep sequence array
[:SOURce]	:MARKer [<n>]	Selects between different markers
	[:STATe] ON|OFF	Sets marker on or off
	:FREQuency	Controls frequency at which marker appears
	:AOFF	Turns all markers off
[:SOURce]	:PHASe	Allows control of output signal phase against a reference
	[:ADJust]	Controls phase offset value relative to reference
	:STEP	Controls step size in radians (can specify DEG or RAD)
	:REFerence	An event that allocates current phase as future ref. phase
	:UNIT RADian|DEGree	Specifies unit for query returns and default
[:SOURce]	:PM	Specifies Phase Modulated signal
	:STATe ON|OFF	PM Signal enabled or disabled
[:SOURce]	:ROSCillator	Controls reference oscillator
	:SOURce INTernal|EXTernal|CLK 10	Selects reference oscillator to lock to
	:AUTO ON|OFF|ONCE	Allows instrument to "decide" INT or EXT
[:SOURce]	:SWEep	Controls generation of a sweep signal
	:TIME	Sets duration of sweep
	:RETRace	Sets duration of sweep retrace time
	:AUTO ON|OFF|ONCE	Couples or isolates RETRace time to/from TIME
		ONCE = AUTO:ON, AUTO:OFF
:STATus	:OPERation	Allows access to operation status register
	[:EVENt]?	Returns content of associated event register
	:CONDition?	Returns content of associated condition register
	:ENABle <integer no.>	Allows event register to be pre-loaded
	:ENABle?	Read event register
	:PTRansition <integer no.>	Loads a positive transition filter
	:PTRansition?	Reads the positive transition filter
	:NTRansition <integer no.>	Loads a negative transition filter
	:NTRansition?	Reads the negative transition filter

SCPI Command Quick Reference (continued)

Command	Sub-command & Parameter	Description
:STATus	:QUEStionable	Same as Operation but on Ques. status register
	:FREQ	Allows operations on assoc. Ques. Frequency register
:STATus	:PREset	Loads status register with preset pattern
:SYSTem	:ERROR?	Returns error number to controller
	:PREset	Presets instrument to known state
	:VERSion	Returns SCPI version compatible with instrument

Common Command Summary

Command	Function
*CLS	Clears instrument status, leaves it Idle
*ESE	Sets Standard Event Status ENABLE register
*ESE?	Returns content of Standard Event Status ENABLE register
*ESR?	Returns content of Standard Event Status register
*IDN?	Identification Query, instrument identifies itself
*OPC	Operation Complete, ensures input queue is parsed, sweep is no longer running, then sets "completed" bit in event register
*OPC?	Operation Complete Query
*RCL<n>	Recall instrument setting n
*RST	Reset, resets instrument to known state
*SAV<n>	Save instrument setting n
*SRE	Service Request Enable, presets bits in SRE register
*SRE?	Service Request Enable Query, returns content of SRE register
*STB?	Read Status Byte Query, returns value of status register content
*TST?	Self Test Query, commands instrument to self test and output result
*WAI	Wait to Continue, causes instrument to halt until sweep is no longer running

E

Error Messages

Introduction

This chapter contains a list of the HP E1440A device-dependent error messages. In addition to them, the E1440 command parser issues syntax error messages. These syntax error messages are normally self-explanatory, e.g. "Number overflow", They are defined by IEEE 488.2 and the TMSL standard.

The types of error which would occur in the HP E1440A fall into a narrow band within the standard VXIbus error messages allowed. The HP E1440A is able to add an appropriate comment to an error message, in order to provide further information. For this reason, most error messages will appear in this list several times, but with a different qualifying message.

Message List

+100,"Query not allowed; Cannot interrogate frequency in mode SWEEP/LIST"
Triggered by :FREQ? command. The current frequency cannot be interrogated while FREQ:MODE is LIST or SWEEP.

-108,"Parameter not allowed; Parameter list is too long (>50 parameters)"
Triggered by :LIST:FREQ:xxxx commands or LIST:DWELl command. Attempt to program one of the lists mentioned below with more than 50 parameters.

-108,"Parameter not allowed; Sequence is too long to be stored"
Triggered by :LIST:SEQ command. Attempt to program a sequence that needs more than 300 entries. The required number of entries is: (the number of single points) + (number of ranges * 3).

-200,"Execution error; No external reference signal detectable"
Triggered by :ROSC:SOUR command. Attempt to select reference oscillator source EXT and no AC signal is detectable on the front panel 'Ext Ref in' connector.

+200,"Command not allowed; Amplitude is 0(fixed) for DC function"
Triggered by :VOLT command. In DC function, only the offset and not the amplitude can be modified.

+200,"Command not allowed; Cannot accept command in mode SWEEP/LIST"
Triggered by: all commands that attempt to alter parameters in the SWEEP/LIST subsystem. Also *SAV, *TST? and CAL?. Switch FREQ:MODE to CW or FIX beforehand.

+200,"Command not allowed; Cannot accept frequency for DC function"
Triggered by :FREQ command. Attempt has been made to enter frequency while output function is DC, the two actions are incompatible

+200,"Command not allowed; Cannot accept phase for DC function"
Triggered by :PHAS command. Attempt to enter phase while output function is DC, this is not possible

+200,"Command not allowed; Parameter is fixed for TTL function"
Triggered by :VOLT or VOLT:OFFS command. The main output is always off in TTL function, the only output is the SYNC output. The SYNC signal characteristic is not alter able.

-213,"Init ignored; Sweep is currently running or frequency mode is FIX"
Triggered by :INIT. Attempt to start a sweep while sweep is already running or while frequency mode is fixed (non sweeping).

-221,"Settings conflict; AC Voltage in Vrms/dBm out of range in new function"
Triggered by :FUNC command. The instrument maintains the output voltage over function changes in the current default unit. If the current default unit is not V (VRMS or dBm) a value legal for one output function, may not be legal for another.

In other words : the Vpp voltage that represents X dBm in SIN function is different from the Vpp voltage for X dBm in SQU function .

-221,"Settings conflict; Active marker in logarithmic interval"
Triggered by :FREQ:MODE command. One of the in-sequence intervals used, has spacing LOG and a marker ON.

-221,"Settings conflict; Active marker outside sweep span"
Triggered by :FREQ:MODE command. There is a marker switched on outside the frequency span defined by start and stop.

-221,"Settings conflict; Already another marker trigger on"
Triggered by :OUTP:TTLT:STAT and OUTP:TTLT:SOUR command. Cannot accept marker trigger on, because another marker trigger is on. The marker trigger can only be applied to one line.

-221,"Settings conflict; Already another sync trigger on"
Triggered by :OUTP:TTLT:STAT and OUTP:TTLT:SOUR command. Cannot accept sync trigger on, because another sync trigger is on. The sync trigger can only be applied to one line.

-221,"Settings conflict; AM allowed for function sines only"
Triggered by :FUNC or AM command. It is not permissible to switch AM on while function is not SIN and (vice versa) nor is it permissible to select a function other than SIN while AM is on.

-221,"Settings conflict; Current output function is not sweep able"
Triggered by :FREQ:MODE command. Attempt to switch frequency mode to SWEEP or LIST while function is DC or TTL.

-221,"Settings conflict; Frequency too high for post amplifier"
Triggered by :FREQ or OUTP:AMPL command. If post amplifier state ON, the frequency is limited to 1 MHz.

-221,"Settings conflict; Frequency too high for TTL trigger lines"
Triggered by :FREQ or OUTP:TTLT command. If SYNC signal is routed to one of the 8 TTL trigger lines and the line driver is enabled, the frequency is limited to 10 MHz (VXI back plane bandwidth).

-221,"Settings conflict; Lists are too short for sequence"
Triggered by: FREQ:MODE command. There is an index in the sweep sequence that is higher than the length of the lists.

-221,"Settings conflict; List lengths are different and not 1"
Triggered by: FREQ:MODE command. All lists (start, stop, mark, spacing, marker on and dwell) must have the same length or must have the length 1. (A list with length 1 is treated as a list of the required length with the entry in slot 1 duplicated as often as necessary.)

-221,"Settings conflict; No dBm allowed when post amplifier is active"
Triggered by: VOLT or OUTP:AMPL command. It is not permissible to program a dBm voltage while the post amplifier is active and (vice versa) and it is not permissible to switch the post amplifier on while the current voltage unit is dBm.

-221,"Settings conflict; No room for markers"
Triggered by: FREQ:MODE command. Time distance between start and stop frequency is too short to place a marker in between. (The minimal distance between start -▸ marker, marker -▸ marker or marker -▸ stop is 1.5 ms.)

-221,"Settings conflict; Span for LOG interval too low (< 1 decade)"
Triggered by: FREQ:MODE command. Stop frequency of a LOG interval is less than 10 times start frequency.

-221,"Settings conflict; Start frequency for LOG interval too low (< 1)"
Triggered by: FREQ:MODE command. Start frequency of one of the LOG intervals is less than 1 Hz.

-221,"Settings conflict; Start frequency too high for post amplifier"
Triggered by: FREQ:MODE command. If post amplifier state ON, the start frequency is limited to 1 MHz.

-221,"Settings conflict; Start frequency too high for TTL trigger lines"
Triggered by: FREQ:MODE command. If SYNC signal is routed to one of the 8 TTL trigger lines and the line driver is enabled, the start frequency is limited to 10 MHz (VXI back plane bandwidth).

-221,"Settings conflict; Stop frequency of LOG interval is lower than start"
Triggered by: FREQ:MODE command. LOG interval has been used with negative span (stop < start).

-221,"Settings conflict; Stop frequency too high for post amplifier"
Triggered by: FREQ:MODE command. If post amplifier state ON, the stop frequency is limited to 1 MHz.

-221,"Settings conflict; Stop frequency too high for TTL trigger lines"
Triggered by: FREQ:MODE command. If SYNC signal is routed to one of the 8 TTL trigger lines and the line driver is enabled, the stop frequency is limited to 10 MHz (VXI back plane bandwidth).

-221,"Settings conflict; Sync and Marker cannot drive the same trigger line"
Triggered by: OUTP:TTLT:STAT and OUTP:TTLT:SOUR command. Cannot accept sync trigger and marker trigger on the same line

-221,"Settings conflict; Time distance start-mark-stop too low (<1.5 ms)"
Triggered by: FREQ:MODE command. The minimal distance between start -> marker, marker -> marker or marker -> stop is 1.5 ms.

-222,"Data out of range; AC Voltage is out of range"
Triggered by: VOLT command. Requested AC voltage is out of absolute bounds.

-222,"Data out of range; AC Voltage is incompatible with DC offset"
Triggered by: VOLT or VOLT:OFFS command. The peak output level (abs(OFFSET) + 1/2 VOLTAGE) that would result, exceeds the output amplifier limits.

-222,"Data out of range; Active marker is out of interval"
Triggered by: FREQ:MODE command. One of the switched ON markers is outside the interval borders. There is a 1.5 ms minimal distance between the marker and the start/stop point.

-222,"Data out of range; Any list frequency is out of range"
Triggered by: FREQ:MODE command. Any one of the list frequencies is too high or negative.

-222,"Data out of range; A list dwell time is out of range"
Triggered by: OUTP:AMPL command.

-222,"Data out of range; DC Offset is out of range"
Triggered by: VOLT:OFFS command. Requested DC offset voltage is out of absolute bounds.

-222,"Data out of range; Dwell time of LOG interval too low (<0.1s)"
Triggered by: FREQ:MODE command. Dwell time for one of the LOG intervals is less than 0.1 sec.

-222,"Data out of range; Frequency is too low"
Triggered by: FREQ command. FIX frequency is < 0.

-222,"Data out of range; Frequency too high for output function"
Triggered by: FUNC or FREQ command. FREQ is too high for the output function.

-222,"Data out of range; Marker index is out range"
Triggered by: MARK:STAT and MARK:FREQ command. Attempt to set marker index outside the range 1 .. 9.

-222,"Data out of range; Phase offset is out of range (-720 .. 720 deg)"
Triggered by: PHAS command. Attempt to set phase outside the range -720 .. 720 degree.

-222,"Data out of range; *SAV/*RCL register number out of range (0 .. 9)"
Triggered by: *SAV or *RCL command. Command argument (register number) is outside the range 0 .. 9.

-222,"Data out of range; Start frequency in list is too high or negative"
Triggered by: FREQ:MODE command. One of the sequenced start frequencies in the list, is too high or negative.

-222,"Data out of range; Start frequency is too low"
Triggered by: FREQ:MODE command. FREQ:STAR value is too low (negative).

-222,"Data out of range; Start frequency too high for output function"
Triggered by: FREQ:MODE command. FREQ:STAR value is too high for the output function.

-222,"Data out of range; Stop frequency in list is too high or negative"
Triggered by: FREQ:MODE command. One of the sequenced stop frequencies in the list, is too high or negative.

-222,"Data out of range; Stop frequency is too low"
Triggered by: FREQ:MODE command. FREQ:STOP value is too low (negative).

-222,"Data out of range; Stop frequency too high for output function"
Triggered by: FREQ:MODE command. FREQ:STOP value is too high for the output function.

-222,"Data out of range; Sweep span is out of range"
Triggered by: FREQ:MODE command. The requested sweep span would require a start/stop frequency outside the legal range.

-222,"Data out of range; Sweep time is out of range (10 ms .. 100000 s)"
Triggered by: FREQ:MODE command. The SWE:TIME or SWE:RTIM value is out of range.

-222,"Data out of range; Sweep time too low (< 10 ms)"
Triggered by: FREQ:MODE command. The SWEEP:TIME or SWE:RTIM or one of the dwell values used in sequence, is less than 10 ms.

-222,"Data out of range; Too many points in sweep sequence (>100)"
Triggered by: FREQ:MODE command. The expanded length of the sweep sequence is greater than 100.

-222,"Data out of range; Trigger line index is out range"
Triggered by: OUTP:TTLT:STAT and OUTP:TTLT:SOUR command. Attempt to set trigger line index out the range 0 - 7.

-240,"Hardware error; Device bus transfer timed out"
Triggered by: asynchronous check and self test. Device bus transfer poll routine timed out, this is a hardware fault!

-240,"Hardware error; Voltage calibration failed"
Triggered by: FUNC or CAL? command. This is a hardware fault. Please report error and returned value from CAL? command to service personnel.

-241,"Hardware missing; Opt. 001 (post amplifier) not installed"
Triggered by: OUTP:AMPL command post amplifier option 001 is missing. Hardware not installed.

-330,"Self-test failed; Device bus read failed"
Triggered by: *tst? command This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Device bus read/write failed"
Triggered by: *tst? command Device bus read or write does not work. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Frac.-N chip read/write (pattern: 0600000000000000) failed"
Triggered by: *tst? command This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Frac.-N chip read/write (pattern: 0598765432101200) failed"
Triggered by: *tst? command This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; missing Frac.-N chip sweep interrupt"
Triggered by: *tst? command This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Operating system timer interrupt missing"
Triggered by: *TST? command. The 10ms timer interrupt for the operating system is not detectable. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Operating system timer period time too high"
Triggered by: *TST? command. The period of the 10 ms opsys timer is significantly greater than 10 ms. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Operating system timer period time too low"
Triggered by: *TST? command. The period of the 10 ms opsys timer is significantly less than 10 ms. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Sweep timer interrupt missing"
Triggered by: *TST? command. The 1 ms timer interrupt derived from frac-n reference clock is not detectable. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Sweep timer period time too high"
Triggered by: *TST? command. The period of the 1 ms sweep timer is significantly greater than 1 ms. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Sweep timer period time too low"
Triggered by: *TST? command. The period of the 1 ms sweep timer is significantly less than 1 ms. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; RAM test failed"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; ROM test failed"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; unexpected Frac.-N chip sweep interrupt"
Triggered by: *tst? command This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; VCO 30 MHz minus unlocked"
Triggered by: *tst? command VCO unlocked by 30 MHz and minus bit. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; VCO 30 MHz plus unlocked"
Triggered by: *tst? command VCO unlocked by 30 MHz and plus bit. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; VCO 60 MHz minus unlocked"
Triggered by: *tst? command VCO unlocked by 60 MHz and minus bit. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; VCO 60 MHz plus unlocked"
Triggered by: *tst? command VCO unlocked by 60 MHz and plus bit. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Voltage calibration failed: level FLIP FLOP is defect"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Voltage calibration failed: level never above low signal peak"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Voltage calibration failed: level never above high signal peak"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Voltage calibration failed: level never below high signal peak"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Voltage calibration failed: level never below low signal peak"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Voltage calibration failed: dc offset ripple too high"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

-330,"Self-test failed; Voltage calibration failed: offset or gain out of range"
Triggered by: *TST? command. This is a hardware fault. Please report error and returned value from *TST? command to service personnel.

Index

S

T

V

W

X