



HP 75000 SERIES C

1 GSa/s Digitizing Oscilloscope HP E1428A

Service Manual

Enclosed is the Service Manual for the HP E1428A 1 GSa/s Digitizing Oscilloscope. Insert this manual into the binder that came with the HP E1428A User's Manual.



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Manual Part Number E1428-97002

Printed: January 1999
Printed in U.S.A.

HP 75000 SERIES C

1 GSa/s Digitizing Oscilloscope HP E1428A

Service Manual

Serial Numbers

Attached to the backplane connector of the instrument is a serial number plate. The serial number is in the form: 0000A00000. The first four digits and the letter are the serial number prefix. The last five digits are the suffix. The prefix is the same for identical instruments; it changes only when a configuration change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument.

This manual applies directly to instruments with serial numbers prefixed 3142A and above.



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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.

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Herstellerbescheinigung

Hiermit wird bescheinigt, dass dieses Gerät/System HP E1428A in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funktionsfähig ist. Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

Zusatzinformation für Mess- und Testgeräte:

Werden Mess- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Messaufbauten verwendet, so ist vom Betreiber sicherzustellen, dass die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

Manufacturer's Declaration

This is to certify that the equipment HP E1428A meets the radio frequency interference requirements of Directive FTZ 1046/84. The German Bundespost has been notified that this equipment was put into circulation and has been granted the right to check the product type for compliance with these requirements.

Additional Information for Test and Measurement Equipment:

If test and measurement equipment is operated with unscreened cables and/or used for measurements on open set-ups, the user has to assure that under operating conditions the Radio Interference Limits are still met at the border of the user's premises.

DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Co.
Manufacturer's Address: Colorado Springs Division
1900 Garden of the Gods Rd.
Colorado Springs, CO 80907 USA

declares that the product

Product Name: Digitizing Oscilloscope Module
Model Number(s): HP E1428A
Product Option(s): All

conforms to the following Product Specifications:

Safety: IEC 1010-1:1990+A1 / EN 61010-1:1993
UL 3111
CSA-C22.2 No. 1010.1:1993

EMC: CISPR 11:1990 / EN 55011:1991 Group 1, Class A
IEC 801-2:1991 / EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984 / EN 50082-1:1992 3 V/m, {1kHz 80% AM, 27-1000 MHz}
IEC 801-4:1988 / EN 50082-1:1992 0.5 kV Sig. Lines, 1 kV Power Lines

Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC, and carries the CE-marking accordingly.

This product was tested in a typical configuration with Hewlett-Packard test systems.

Colorado Springs, 11/17/98



Ken Wyatt / Product Regulations Manager

European Contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department ZQ / Standards Europe, Herrenberger Strasse 130, D-71034 Boeblingen, Germany (FAX +49-7031-14-3143)

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.

Edition 1 (Part Number E1428-90902) October 1991
Edition 1 (Part Number E1428-97002) January 1999

Safety Summary

The following general safety precautions must be observed during all phases of operation, service, and repair of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

Ground the equipment: For Safety Class 1 equipment (equipment having a protective earth terminal), an uninterruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.

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

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

Keep away from live circuits: Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers or shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, **DO NOT** perform procedures involving cover or shield removal unless you are qualified to do so.

DO NOT operate damaged equipment: Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, **REMOVE POWER** and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DO NOT service or adjust alone: Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT substitute parts or modify equipment: Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

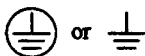
Safety Symbols

~ LINE

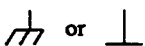


AC line voltage input receptacle.

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



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



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



Alternating current (AC).



Direct current (DC).



Indicates hazardous voltages.



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

NOTE

Calls attention to a procedure, practice, or condition that requires special attention by the reader.

WARNING

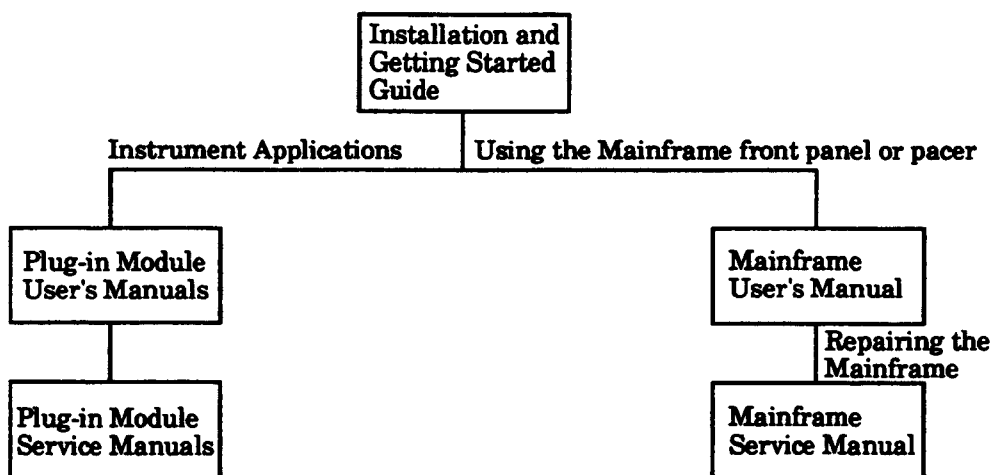
Calls attention to a procedure, practice, or condition that could cause bodily injury or death.

CAUTION

Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

HP 75000 Series C Documentation

Suggested Sequence for Using the Available Manuals



Manual Descriptions

Installation and Getting Started Guide. Contains step-by-step instructions for all aspects of plug-in module and mainframe installation. This guide also contains introductory programming information and examples.

HP E1405 Command Module User's Guide. Contains programming information for the Control Module, operation information (for the HP E1400B mainframe), and general programming information for instruments installed in the mainframe.

Plug-In Module User's Manuals. Contains plug-in module programming and configuration information. These manuals contain examples for the most-used module functions, and a complete SCPI command reference for the plug-in module.

HP E1400B Mainframe Service Manual. Contains service information for the mainframe. This manual contains information for ordering replaceable parts and exchanging assemblies. Also contains information and procedures for performance verification, adjustment, preventive maintenance, troubleshooting, and repair.

Plug-In Module Service Manuals. Contains plug-in module service information. These manuals contain information for exchanging the module or ordering replaceable parts. Dependent on the module, information and procedures for performance verification, adjustment, preventive maintenance, troubleshooting, and repair are also provided.

How to Use this Manual

Manual Overview

This manual shows how to service the HP E1428A 250 MHz Digitizing Oscilloscope. Oscilloscope operation, installation, and configuration information is not discussed in this manual. Refer to the "HP 75000 Series C HP E1428A User's Manual" for installation, configuration, and operating information.

Manual Content

This manual has eight chapters and one appendix.

- **Chapter 1 General Information:** provides a basic description, and lists available options and accessories. Also lists the tools and test equipment required for service.
- **Chapter 2 Installation:** contains information and procedures required to install the oscilloscope into the mainframe, perform initial inspection, prepare for use, and storing and shipping instructions.
- **Chapter 3 Operating Instructions:** contains information and procedures required to operate the oscilloscope, perform scheduled preventive maintenance, and perform the operator's check.
- **Chapter 4 Verification Tests:** contains information and procedures required to test the oscilloscope. Three levels are provided for functional verification, operation verification, and performance verification.
- **Chapter 5 Adjustments:** contains information and procedures required to readjust the oscilloscope to within its rated specifications.
- **Chapter 6 Replaceable Parts:** lists the part numbers for all user replaceable parts in the oscilloscope. Also provides information on ordering spare parts and module/assembly exchange.
- **Chapter 7 Manual Changes:** contains information required to adapt this manual to instruments whose serial numbers are lower than those listed on the title page.
- **Chapter 8 Service:** contains information and procedures to aid in fault isolation and repair of the oscilloscope.
- **Appendix A References:** contains a list of all reference documentation required when servicing the oscilloscope.

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General Information

1-1. Introduction

The HP E1428A Service Manual contains all the information required to test, adjust, troubleshoot, and repair the Hewlett-Packard Model E1428A C Size VXI 1 GSa/s Digitizing Oscilloscope. Figure 1-1 shows the HP E1428A Oscilloscope, along with all of the externally supplied accessories. Additional copies of the HP E1428A User's Manual and Service Manual can be ordered separately through your nearest Hewlett-Packard office.

1-2. Specifications Considerations

Instrument specifications are listed in Appendix A of the HP E1428A User's Manual. These specifications are the performance standards or limits against which the instrument may be tested.

1-3. Safety Considerations

This product is a Safety Class I instrument, that is, one provided with a protective earth terminal when installed in the mainframe. The mainframe, oscilloscope, and all related documentation should be reviewed for familiarization with safety markings and instructions before operation or service. Refer to the Safety Considerations page found at the beginning of this manual for a summary of the safety information. Safety information for preventive maintenance, testing, adjusting, or service is found in appropriate places throughout this manual.

1-4. Manual Updates

Manual Updates provide information necessary to update the manual. The Manual Update is identified by the manual print date and part number, both of which appear on the manual title page.

1-5. Description

The Oscilloscope module is a general purpose, two channel, 1 GSa/s (250 MHz repetitive bandwidth) oscilloscope, which provides all the versatility and capability of digitizing oscilloscopes. The Oscilloscope module is a VXIbus C-Size message-based product, and can operate in a single slot of a C-Size VXIbus mainframe using an HP E1405 Command Module.

The Oscilloscope module is comprised of a CPU/Acquisition Printed Circuit Assembly (PCA) (HP P/N E1428-69501) and a Memory PCA (HP P/N E1428-69502).

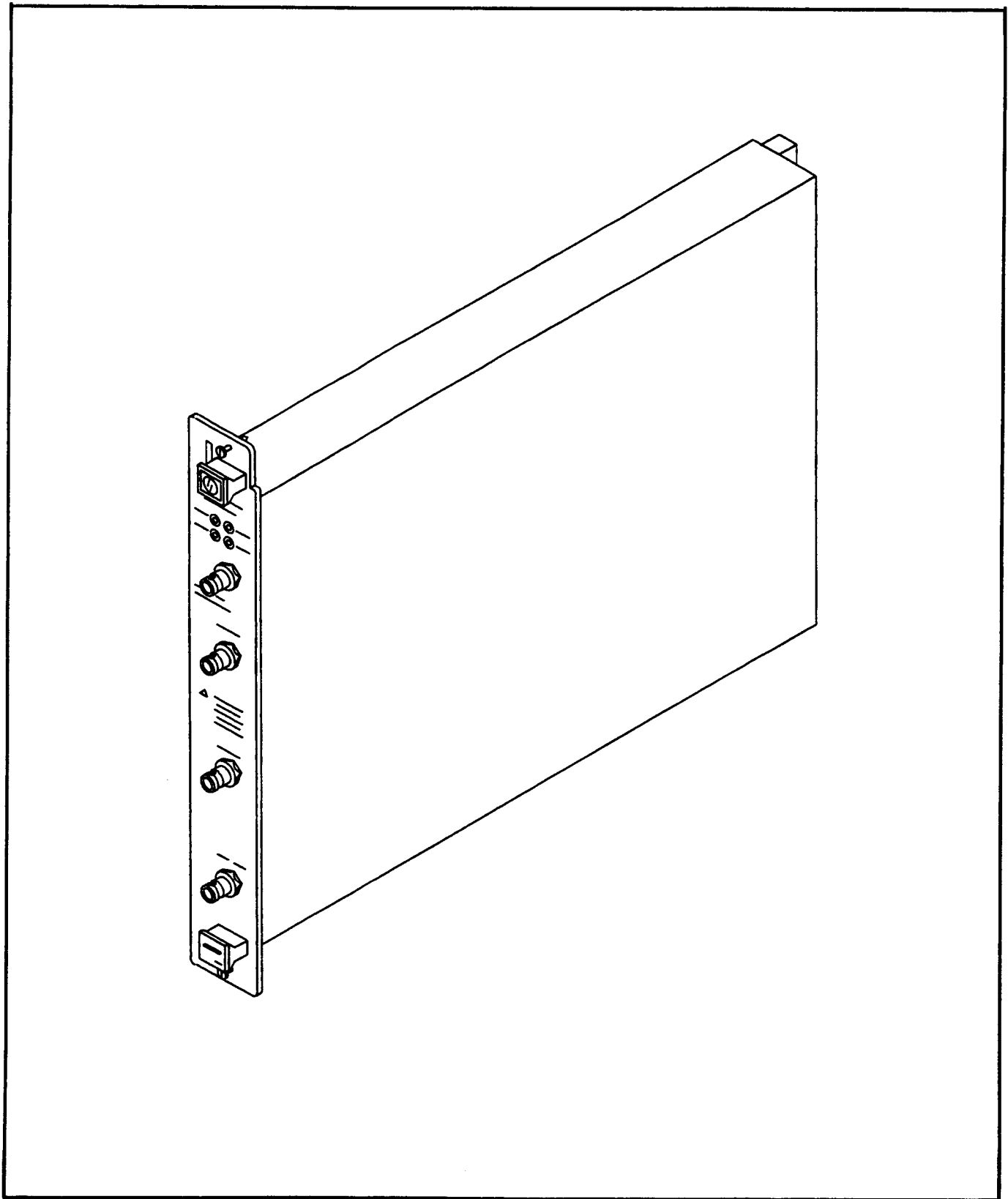


Figure 1-1. HP E1428A/E Digitizing Oscilloscope

The CPU/Acquisition PCA attenuates/amplifies each of the two inputs. The signal is then routed to an A/D Converter where it is changed into a digital word. This digital information is stored for use by the CPU. A replica of the conditioned input signal is also used for triggering. Additional functions include:

- Time base circuit provides the timing signals necessary for data acquisition.
- AC calibrator circuit provides signals for probe compensation, trigger event, and calibration.
- DC calibrator circuit provides a calibration signal.
- External trigger input doubles as external sample clock input.

The CPU/Acquisition PCA also contains the control and interface circuits necessary to direct oscilloscope operations. Control information (COMP or SCPI) is received from the mainframe controller, and the necessary instructions are sent to the Acquisition to perform the specific task. When the digital waveform information is received from the Acquisition, all the user requested parameters are measured and routed to the mainframe. Additional functions include:

- ECL trigger signals from the mainframe are routed to the Acquisition portion of the CPU/Acquisition PCA to perform "backplane trigger" functions.
- ECL trigger signals from the oscilloscope are routed to the mainframe over the backplane trigger bus lines.
- Trigger circuit provides a trigger output signal on the front panel.

Refer to appendix C in the HP E1428A User's Manual for additional information on the HP E1428A Oscilloscope.

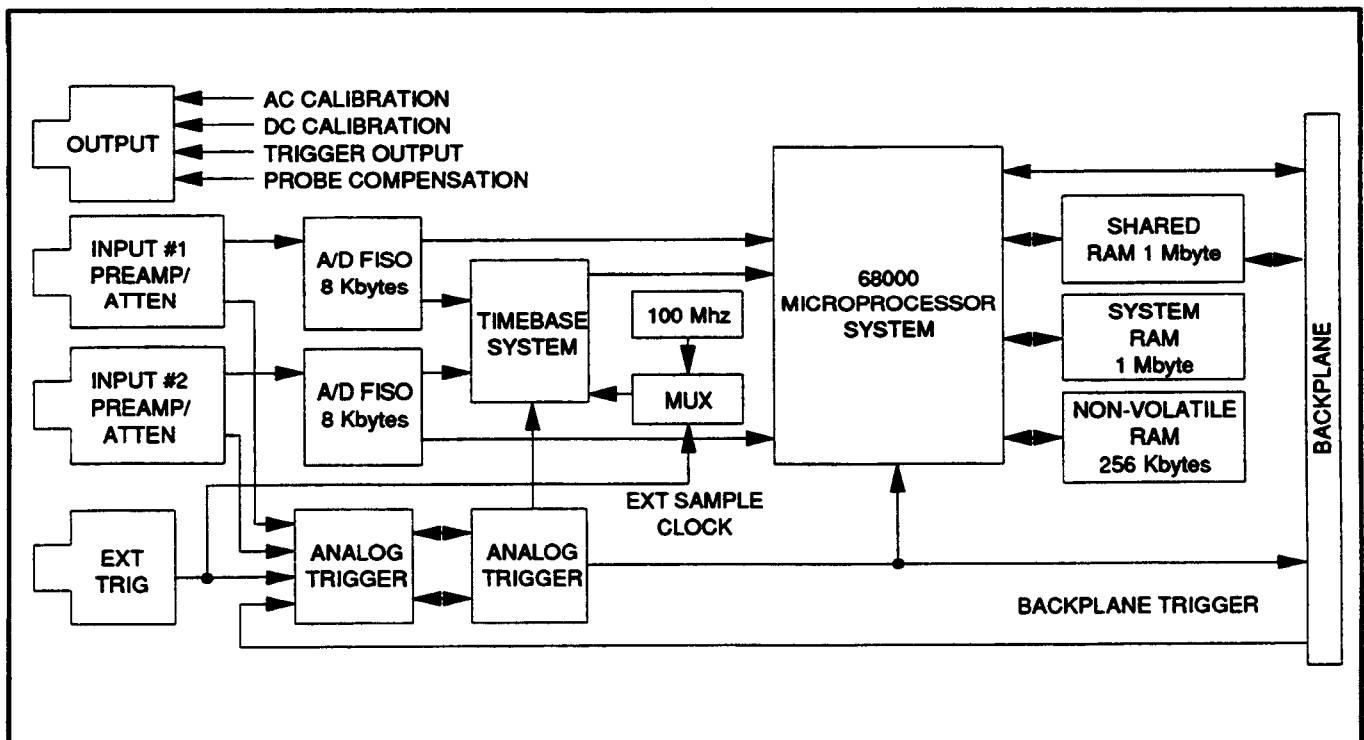


Figure 1-2. Oscilloscope Module Block Diagram

1-6. Instruments Covered by this Manual

Instruments covered by this manual are identified by a serial number prefix listed on the title page. Hewlett-Packard uses a two part serial number in the form XXXXAYYYYY, where XXXX is the serial prefix, A is the country of origin (A=USA) and YYYYY is the serial suffix. The serial number prefix identifies a series of identical instruments. The serial number suffix is assigned sequentially and is unique to each instrument. If the serial number prefix of your instrument is greater than the one listed on the title page, a yellow Manual Update supplement will explain how to adapt this manual to your instrument. If the serial number prefix of your instrument is lower than the one listed on the title page, information contained in Chapter 7 (Manual Changes) will explain how to adapt this manual to your instrument.

1-7. Options

There are no options currently available for the HP E1428A Oscilloscope Module.

1-8. Accessories Supplied

There are no accessories currently available for the HP E1428A Oscilloscope Module.

1-9. Equipment Available

A number of oscilloscope accessories are available for use with the HP E1428A Oscilloscope, and include:

- The HP 1124A Active Divider Probe Kit
- The HP 1133A TV/Video Sync Pod
- The HP 1137A 1000:1 High voltage divider probe
- The HP 1141A/HP 1142A Differential Probe system
- The HP 1250-1454 miniature probe to BNC male adapter
- The HP 10002A 50:1 Voltage Divider Probe
- The HP 10020A Resistive Divider Probe Kit
- The HP 10400A Miniature Probe Family

For a complete list of oscilloscope accessories currently available, contact your nearest Hewlett-Packard sales office.

1-10. Recommended Test Equipment

Table 1-1 lists the test equipment recommended for testing, adjusting and servicing the oscilloscope. Essential requirements for each piece of test equipment are described in the Critical Specifications column. Other equipment can be substituted if it meets or exceeds the critical specifications.

Table 1-1. Recommended Test Equipment

Instrument	Critical Specifications	Recommended Model	Use*
Controller, HP-IB	HP-IB compatibility as defined by IEEE Standard 488-1978 and the identical ANSI Standard MC1.1: SH1, AH1, T2, TE0, L2, LE0, SR0, RL0, PP0, DC0, DT0, and C1, 2, 3, 4, 5.	HP Series 200/300	P,A,T
Mainframe	Compatible with the oscilloscope	HP E1400B	P,A,T
Slot 0 Command Module	VXI "C" size w/HPIB	HP E1405A	P,A,T
Digital Multimeter	5 1/2 digit resolution dc voltage accuracy 8 ppm/yr 4-wire resistance accuracy $\pm 0.25\%$	HP 3458A	P,T
Fast-rise Pulse Generator	Rise Time < 175ps (faster is better)	PSPL 1110B driver (note) PSPL 1107B head (note)	A
Oscilloscope	General-purpose	HP 54501A	T
Power Meter/Power Sensor	1-250 MHz, -70 dBm to +44 dBm, 3% accuracy	HP 436A/8482A	P
Power Splitter	50 Ω type N, outputs differ by <0.15 dB	HP 11667A	P
Power Supply	7 mV -30 V dc, 0.1 mV resolution	HP 6114A	P
Signal Generator	1-250 MHz, sine wave amplitude 30-200 mVrms time base accuracy $\pm 0.001\%$	HP 8656B, Opt 001	P
Pulse Generator	$\tau = 1.0$ to 1.4 ns, 280 mVp-p, externally triggerable	HP 8161A	P
Blocking Capacitor	0.18 μ F	HP 10240B	P
Cables and Adapters			
Adapter (2)	BNC (f) to dual banana (m)	HP 1251-2277	P
Adapter (3)	BNC tee (m)(f)(f)	HP 1250-0781	P,T
Adapter	BNC (f)(f)	HP 1250-0080	T
Adapter	N (f) to BNC (m)	HP 1250-0077	A
Adapter	N (m) to BNC (f)	HP 1250-0780	P
Adapter	N (m) to BNC (m)	HP 1250-0082	P
Adapter	SMA (m) to BNC (m)	HP 1250-1787	A
Cable (2)	BNC - 3 foot	HP 10503A	P,A,T
Cable (3)	BNC - 9 inch	HP 10502A	P,A,T
Cable	Type N (m) (m) - 3 foot	HP 11500A or B	P
Shorting Cap	BNC	HP 1250-0774	P
Note PPL = Picosecond Pulse Labs * M = Preventative Maintenance, F = Functional Verification Check, C = Operational Verification Tests, P = Performance Verification Tests, A = Adjustments, T = Troubleshooting			

2-1. Introduction

This chapter provides the information needed to install the HP E1428A Oscilloscope. Included is information pertinent to initial inspection, preparation for use, environment, storage and shipment.

2-2. Initial Inspection

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).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. Procedures for checking electrical performance are given in Chapter 4. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-3. Preparation for Use

Complete instructions for preparing the HP E1428A Oscilloscope for use are provided in the HP E1428A User's Manual, the HP E1400B Mainframe User's Manual, and the HP E1405 Command Module User's Manual. Procedures include:

HP E1428A User's Manual (Chapter 2)

- Logical Address Switch Selection
- Bus Request/Grant Level Switch Selection
- Connecting User Inputs
- Mainframe Installation

HP E1405 Command Module User's Manual (or applicable command module manual)

- Interface Cable Connection
- Addressing the Plug-In Modules
- System Configuration

HP E1400 Mainframe User's Manual (or applicable mainframe manual)

- AC Power Selection and Connection
- Module Installation

2-4. Operating Environment

The operating environment should be within the following limitations

Temperature 0 to +55°C

Humidity 65% relative (0 to +40°C)

2-5. Storage and Shipment

2-6. Environment

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment:

Temperature -40 to +75°C

Humidity <65% relative (0 to +40°C)

2-7. Packaging

Preparation for Packaging. Remove any adapters or connectors before packaging instrument for shipping.

Tagging for Service. If the instrument is being returned to Hewlett-Packard for service, please indicate the required service and observed symptoms/problems, and place it with the instrument.

Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. Mark the container "FRAGILE" to assure careful handling. In any correspondence refer to the instrument by model number and full serial number.

Other Packaging. The following general instructions should be used for re-packaging with commercially available materials:

- Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard office or service center, attach a tag indicating the service desired.)
- Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.
- Use enough shock-absorbing material (75 to 100 mm layer; 3 to 4 inches) around all sides of the instrument to provide firm cushion and prevent movement in the container. Protect the front panel with cardboard.
- Seal the shipping container securely.
- Mark the shipping container "FRAGILE" to assure careful handling.

Operating Instructions

3-1. Introduction

This chapter provides operating information for the HP E1428A Oscilloscope. Included are detailed operator's preventive maintenance procedures, operating instructions, and operator's checks. Both preventive maintenance and the operator's checks should be performed on a regular scheduled basis to keep the oscilloscope in an operational condition, and also prevent more serious malfunctions from occurring.

3-2. Safety Considerations

This paragraph contains information, cautions, and warnings which must be followed for your protection and to avoid damage to the equipment when performing preventive maintenance.

Before applying power, verify that the mainframe (the oscilloscope is installed in) is set to match the available line voltage and the correct fuse is installed. An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

Warning

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.) In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Maintenance described in the manual is performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury. Where maintenance can be performed without power applied, the power should be removed.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.). Do not use repaired fuses or short circuited fuseholders.

Caution

Static electricity is a major cause of component failure. To prevent damage to the electrical components in the Oscilloscope, observe anti-static techniques whenever working on the Oscilloscope.

3-3. Preventive Maintenance

Preventive maintenance for the Oscilloscope consists of periodically cleaning the Oscilloscope.

Note

Hewlett-Packard recommends a 12-month interval between cleaning the Oscilloscope. However, cleaning intervals are mostly dependent upon where the Oscilloscope is used. The Oscilloscope should be cleaned more often if it is used in a dusty or very humid area.

3-4. Required Equipment

Table 3-1 shows the necessary equipment to perform scheduled preventive maintenance.

Table 3-1. Preventive Maintenance Equipment

Description	Requirement
Soft-bristle brush	Removing dust from printed circuit card
Mild Soap Solution	Cleaning panel
Lint-free cloth	Cleaning panel

Warning

Before removing the Oscilloscope from the mainframe, make sure the mainframe is disconnected from the power source, to eliminate the possibility of electrical shock.

3-5. Operation

Complete instructions for operation of the Oscilloscope are provided in the HP E1428A User's Manual. Information includes:

- Getting Started
- Configuring the Oscilloscope
- Using the Oscilloscope with COMPatible or SCPI
- Oscilloscope Command References in COMPatible and SCPI
- Error Messages in COMPatible and SCPI

3-6. Operator's Checks

The operator's checks should be performed after preventive maintenance (minimum), or any time to verify that the Oscilloscope is connected properly and is responding to the simplest commands.

Note

If necessary, refer to the HP E1405 Command Module User's Manual (or applicable command module manual) for information on address selection and external cabling guidelines.

Refer as required to the HP E1428A User's Manual for information on SCPI and COMPatible commands.

1. Verify the Oscilloscope and Command Module are installed in the mainframe.
2. On the mainframe, connect a power cable and set the power to ON. Verify the mainframe/command module performs a proper power-up sequence.
 - If correct, proceed with step 3.
 - If incorrect, troubleshoot mainframe/command module before proceeding.
3. Perform clear status, reset, then preset the Oscilloscope.

4. Execute the Oscilloscope functional test using the **TEST:TALL** command.
5. Allow approximately 15 seconds for the test to complete, then read the test event register to verify that no errors were generated during the test.
 - If +0 is returned, then no failure was encountered.
 - If any number other than 0 is returned, then a failure was detected. See Chapter 8 for troubleshooting information.

Note

Test failures can be caused by improper cabling, or improper selection of the interface select code, primary address setting, and/or secondary address setting. Verify proper connection and address selection using the applicable command module and mainframe manuals before troubleshooting.

Example

For the example, use:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the Oscilloscope
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

10	OUTPUT 70905;"*CLS"	<i>Clear status.</i>
20	OUTPUT 70905;"*RST"	<i>Resets the Oscilloscope to its default state.</i>
30	OUTPUT 70905;"SUMM:PRES"	<i>Presets the Oscilloscope.</i>
40	OUTPUT 70905;"TEST:TALL"	<i>Perform all test routines.</i>
50	OUTPUT 70905;"SUMM:QUES:TEST?"	<i>Read test event register.</i>
60	ENTER 70905;A	<i>Enter test event register results.</i>
70	PRINT A	<i>Print test event register results.</i>
80	OUTPUT 70905;"RUN"	<i>Restart the instrument.</i>
90	END	<i>Terminate program.</i>

Note

After a self-test is performed, the **RUN** command must be executed to restart the instrument.

Verification Tests

4-1. Introduction

Three levels of test procedures are provided in this chapter, and are used to verify that the HP E1428A Oscilloscope is:

- fully functional (Functional Verification),
- meeting critical specifications after a repair (Operation Verification), or
- meeting all published specifications (Performance Verification).

Note

To consider the tests valid, the following conditions must be met:

- The HP E1428A must have a 30 minute warm-up.
 - For greatest accuracy, the temperature of the test area should be between 18°C and 28°C and should be stable to within $\pm 1^\circ\text{C}$.
-

4-2. Equipment Required

Equipment required for the verification tests is listed in Table 1-1, Recommended Test Equipment. Any equipment that satisfies the critical specifications given in the table may be substituted.

4-3. Test Record

Results of the verification tests may be tabulated in Table 4-1, Verification Test Record. The Verification Test Record lists all of the verification test specifications and the acceptable limits for each specification. If verification test results are recorded during an incoming inspection of the instrument, they can be used for comparison during periodic maintenance or troubleshooting. The test results may also prove useful in verifying operation after repairs are made.

4-4. Calibration Cycle

This instrument requires periodic verification of performance to ensure that it is operating within specified tolerances. The performance verification tests described in this section should be performed at least once every 12 months or 2,000 hours; under conditions of heavy usage or severe operating environments, the tests should be more frequent.

4-5. Test Procedures

It is assumed that the person performing the verification tests understands how to operate the mainframe, HP E1428A, and specified test equipment. Equipment settings, other than those for the HP E1428A, are stated in general terms. For example, a test might require that a voltage of +5 Vdc be measured, however the Digital Multimeter instructions as to mode and range would not be specified and the operator would be expected to set that control and other controls as required to obtain a measurement. It is also assumed that the technician will select the cables, adapters, and probes required to complete the test setups illustrated in this section.

4-6. Functional Verification

The procedures in this section are used to quickly verify that the HP E1428A functions are working. These tests should be performed anytime the user wants to verify that the HP E1428A is connected properly and is responding to basic commands. All tests can be performed without accessing the interior of the instrument.

4-7. Self-Test Procedure

The purpose of this test is to verify the HP E1428A is communicating with the command module, external controller, and/or external terminal by performing a self-test.

Note

If necessary, refer to the HP E1405 Command Module User's Manual (or applicable command module manual) for information on address selection and external cabling guidelines.

Refer as required to the HP E1428A User's Manual for information on SCPI and COMPAtible commands.

1. Verify the HP E1428A and Command Module are installed in the mainframe.
2. On the mainframe, connect a power cable and set the power to ON. Verify the mainframe/command module performs a proper power-up sequence.
 - If correct, proceed with step 3.
 - If incorrect, troubleshoot mainframe/command module before proceeding.
3. Perform clear status, reset, then preset the HP E1428A.
4. Execute the test all routine using the **TEST:TALL** command.
5. Allow approximately 15 seconds for the test to complete, then read the test event register to verify that no errors were generated during the test.
 - If +0 is returned, then no failure was encountered.
 - If any number other than 0 is returned, then a failure was detected. See Chapter 8 for troubleshooting information.

Note

Test failures can be caused by improper cabling, or improper selection of the interface select code, primary address setting, and/or secondary address setting. Verify proper connection and address selection using the applicable command module and mainframe manuals before troubleshooting.

Example

For the example, use:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPAtible programming language
- an HP Series 200/300 Computer with HP BASIC

10	CLEAR SCREEN	<i>Clear display.</i>
20	ASSIGN @Scope TO 70905	<i>Variable for Scope address.</i>
30	OUTPUT @Scope;"*CLS"	<i>Clear status.</i>
40	OUTPUT @Scope;"*RST"	<i>Resets the HP E1428A to its default state.</i>
50	OUTPUT @Scope;"SUMM:PRES"	<i>Presets the HP E1428A.</i>
60	OUTPUT @Scope;"TEST:TALL"	<i>Perform test all routine.</i>
70	OUTPUT @Scope;"SUMM:QUES:TEST?"	<i>Read test event register.</i>
80	ENTER @Scope;A	<i>Enter test event register results.</i>
90	PRINT A	<i>Print test event register results.</i>
100	OUTPUT @Scope;"RUN"	<i>Restart the instrument.</i>
110	PRINT "PROGRAM COMPLETED"	<i>End of program.</i>
120	END	<i>Terminate program.</i>

Note

After a test all is performed, the RUN command must be executed to restart the instrument.

4-8. Operation Verification

There are no operation verification procedures for the HP E1428A. Use the Performance verification test procedures for post repair check-out.

4-9. Performance Verification

The procedures in this section are used to test the HP E1428A Oscilloscope modules electrical performance using the specifications in Appendix A of the HP E1428A User's Manual as the performance standards. These tests are suitable for incoming inspection, troubleshooting, and preventive maintenance. All tests can be performed without accessing the interior of the instrument.

4-10. DC Calibrator Test Procedure

The DC CALIBRATOR output on the front panel is used for self-calibration and probe calibration. Though calibrator accuracy is not specified in the performance specifications, it must be within limits in order to provide accurate self-calibration.

1. Connect the equipment as shown below.

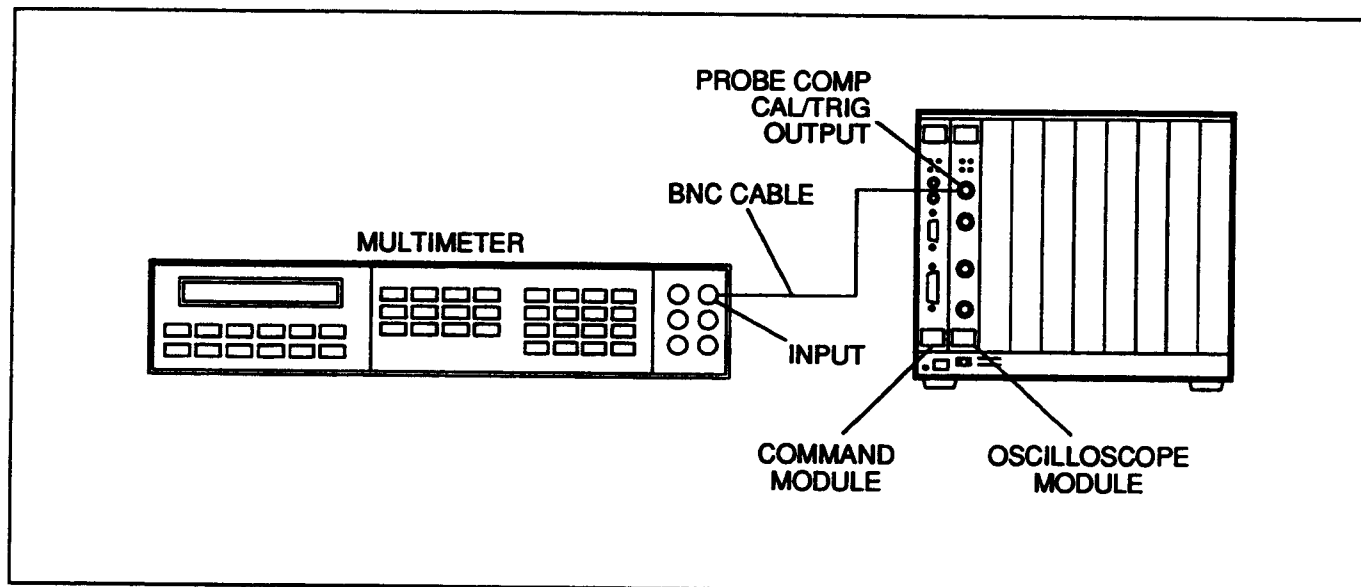


Figure 4-1. DC Calibrator Test Set-up

2. Set the HP E1428A controls as follows:

Reset HP E1428A *RST
DC Calibrator Output to 0 V CAL:SCAL:DOUT ZVOL

3. Verify the Multimeter reads close to 0.000 V. Record the reading to four decimal places.

V1 = _____.

4. Set the HP E1428A Calibrator Output to 5 V (CAL:SCAL:DOUT FVOL).

5. Verify the Multimeter reads close to 5.000 V. Record the reading to four decimal places.

V2 = _____.

6. Subtract V1 from V2. The difference should be between 4.990 and 5.010 V.

Note

If the difference is not within the limits repair is necessary. See troubleshooting in Chapter 8.

7. Disconnect test equipment.

Example This program will automatically perform a DC Calibrator test. The program will pause to allow the user to get the reading from the multimeter.

The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```
10  CLEAR SCREEN
20  ASSIGN @Scope TO 70905      ! USE A VARIABLE FOR SCOPE ADDRESS
30  OUTPUT @Scope;"*CLS"
40  OUTPUT @Scope;"*RST"
50  OUTPUT @Scope;"CAL:SCAL:DOUT ZVOL"
60  PRINT "LOOK AT MULTIMETER AND VERIFY 0 VOLT OUTPUT"
70  PRINT "PRESS Continue TO RESUME PROGRAM"
80  PAUSE
90  OUTPUT @Scope;"CAL:SCAL:DOUT FVOL"
100 PRINT "LOOK AT MULTIMETER AND VERIFY 5 VOLT OUTPUT"
110 PRINT "PRESS Continue TO FINISH PROGRAM"
120 PAUSE
130 PRINT "PROGRAM COMPLETED"
140 END
```

4-11. Input Resistance Test Procedure

This test checks the input resistance of the vertical inputs. A four-wire measurement is used for accuracy at 50 Ω .

1. Connect the equipment as shown below. Use the BNC-to-banana adapters to connect one of each BNC cable to the four-wire resistance connections on the multimeter, and connect the free ends of the cables to a BNC tee. Connect the male end of the BNC tee to the HP E1428A channel 1 input.

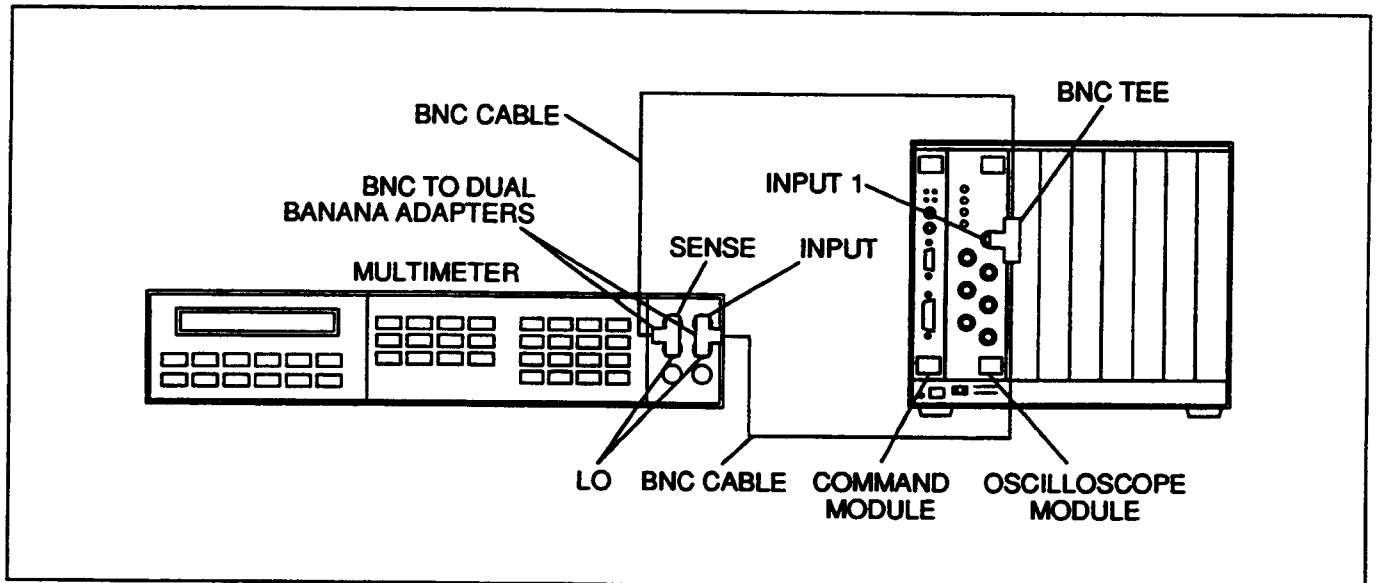


Figure 4-2. Input Resistance Test Set-up

2. Set the HP E1428A controls as follows:

Reset HP E1428A	*RST
Channel 1 DC at 1M Ω	CHAN1:COUP DC

3. Verify the Multimeter reads 1M Ω $\pm$ 10k Ω .
4. Set the HP E1428A channel 1 controls to 50 Ω (CHAN1:COUP DCF).
5. Verify the Multimeter reads 50 Ω $\pm$ 0.5 Ω .
6. Repeat steps 1 through 5 for channel 2.

Notes

When repeating the procedure, all references to channel 1 should be changed to the channel being tested.

Failure of this test indicates a faulty attenuator if resistance is out of specifications. The PCA also may be at fault if input resistance cannot be changed. See troubleshooting in Chapter 8.

7. Disconnect test equipment.

Example This program will automatically prompt the user through the steps required to perform an input resistance test. The program will pause to allow the user to get the reading from the multimeter.

The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```
10  CLEAR SCREEN
20  ASSIGN @Scope TO 70905      ! USE A VARIABLE FOR SCOPE ADDRESS
30  OUTPUT @Scope;"*CLS"
40  OUTPUT @Scope;"*RST"
50  FOR Channel=1 TO 2
60      PRINT "CONNECT THE MULTIMETER TO SCOPE CHANNEL "&VAL$(Channel)
70      PRINT "1 MOHM"
80      OUTPUT @Scope;"CHAN"&VAL$(Channel)&":COUP DC"
90      PAUSE
100     PRINT "50 OHM"
110     OUTPUT @Scope;"CHAN"&VAL$(Channel)&":COUP DCF"
120     PAUSE
130 NEXT Channel
140 OUTPUT @Scope;"*RST"
150 PRINT "PROGRAM COMPLETED"
160 END
```

4-12. Voltage Measurement Accuracy Test Procedure

This test verifies the voltage measurement accuracy of the instrument. A dual cursor measurement is made so offset errors are not a factor.

1. Connect the equipment as shown below. Use a banana-to-BNC adapter to connect the BNC cable to the power supply. Monitor the supply with the Multimeter. Set the power supply for 0 V output.

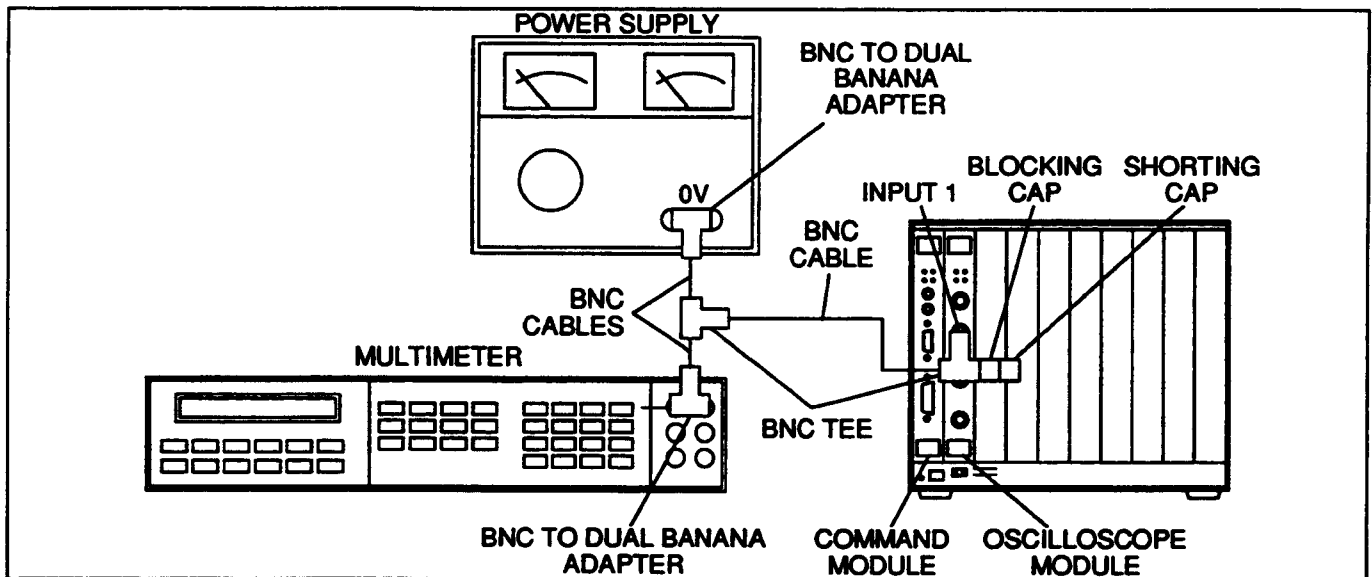


Figure 4-3. Voltage Measurement Accuracy Test Set-up

2. Set the HP E1428A controls as follows:

Reset HP E1428A	*RST
Time base to automatic	TIM:MODE AUT
Start data acquisition	RUN
Turn on channel 1	VIEW CHAN1
Turn off unused channels	BLAN CHAN2
Channel 1 to DC at 1MΩ	CHAN1:COUP DC
Channel 1 range to 40 V	CHAN1:RANG 40
Channel 1 offset to 15 V	CHAN1:OFFS 15
Measure channel 1	MEAS:SOUR CHAN1
Digitize channel 1	DIG CHAN1
Measure voltage	MEAS:VTOP?

3. Verify that average voltage as measured by the HP E1428A is close to 0 volts. Record the reading.

V1 = _____.

4. Set the power supply to output 30 Vdc. Repeat steps 2 and 3. Record the reading.

V2 = _____.

5. Subtract V1 from V2. The difference should be between 29.34 V and 30.66 V.

6. Repeat steps 2 through 5 for all the HP E1428A RANGE and OFFSet values, and power supply voltages specified in the table below.

RANGE	OFFSet	Power Supply	Tolerance	Limits
40 V	15 V	30 V	± 0.66 V	29.34 V to 30.66 V
40 V	15 V	15 V	± 0.66 V	14.34 V to 15.66 V
40 V	15 V	5 V	± 0.66 V	4.34 V to 5.66 V
1.6 V	600 mV	1.2 V	± 26.4 mV	1.1736 mV to 1.2264 mV
1.6 V	600 mV	600 mV	± 26.4 mV	573.6 mV to 626.4 mV
1.6 V	600 mV	200 mV	± 26.4 mV	173.6 mV to 226.4 mV
80 mV	30 mV	60 mV	± 1.32 mV	58.68 mV to 61.32 mV
80 mV	30 mV	30 mV	± 1.32 mV	28.68 mV to 31.32 mV
80 mV	30 mV	10 mV	± 1.32 mV	8.68 mV to 11.32 mV
56 mV	21 mV	42 mV	± 0.924 mV	41.076 mV to 42.924 mV
56 mV	21 mV	21 mV	± 0.924 mV	20.076 mV to 21.924 mV
56 mV	21 mV	7 mV	± 0.924 mV	6.076 mV to 7.924 mV

7. Repeat steps 2 through 6 for channel 2.

Notes

When repeating the procedure, all references to channel 1 should be changed to channel 2. Turn off unused channel using the BLANK command.

Voltage measurement errors can be caused by the need for self calibration. Perform vertical calibration, (see Adjustment procedures, Chapter 5) before troubleshooting instrument. If self-calibration fails to correct problem, the cause may be the attenuator or PCA. See troubleshooting in Chapter 8.

8. Disconnect test equipment.

Example This program will automatically prompt the user through the steps required to perform a voltage accuracy test, and print out the results of each measurement. The data at the end of the program corresponds to the values for range, offset and supply voltage in each measurement.

The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  CLEAR SCREEN
20  ASSIGN @Scope TO 70905
30  OPTION BASE 1
40  DIM Range(12),Offset(*),Power_supply(*),Zero_offset(12)
50  RESTORE
60  READ Range(*),Offset(*),Power_supply(*)
70  OUTPUT @Scope;"*CLS"
80  OUTPUT @Scope;"*RST"
90  FOR Channel=1 TO 2
100  OUTPUT @Scope;"TIM;MODE AUT"
110  OUTPUT @Scope;"RUN"
120  OUTPUT @Scope;"BLAN CHAN1,CHAN2"
130  OUTPUT @Scope;"VIEW CHAN"&VAL$(Channel)
140  OUTPUT @Scope;"CHAN"&VAL$(Channel)&":COUP DC"
150  PRINT "CONNECT THE POWER SUPPLY TO SCOPE CHANNEL "&VAL$(Channel)
160  FOR Measurement=1 TO 12
170  PRINT "SET THE POWER SUPPLY TO 0 VOLTS"
180  PAUSE
190  OUTPUT @Scope;"CHAN"&VAL$(Channel)&":RANG "&VAL$(Range(Measurement))
200  OUTPUT @Scope;"CHAN"&VAL$(Channel)&":OFFS "&VAL$(Offset(Measurement))
210  OUTPUT @Scope;"MEAS:SOUR CHAN"&VAL$(Channel)
220  OUTPUT @Scope;"DIG CHAN"&VAL$(Channel)
230  OUTPUT @Scope;"MEAS:VTOP?"
240  ENTER @Scope;Zero_val
250  PRINT "SET THE POWER SUPPLY TO "&VAL$(Power_supply(Measurement))&" VOLTS"
260  PAUSE
270  OUTPUT @Scope;"DIG CHAN"&VAL$(Channel)
280  OUTPUT @Scope;"MEAS:VTOP?"
290  ENTER @Scope;Voltage_val
300  Result=Voltage_val-Zero_val
310  PRINT "RESULT = "&VAL$(Result)
320  NEXT Measurement
330  NEXT Channel
340  OUTPUT @Scope;"*RST"
350  !RANGE VALUES FOR EACH MEASUREMENT
360  DATA 40,40,40,1.6,1.6,1.6,80E-3,80E-3,80E-3,56E-3,56E-3,56E-3
370  !OFFSET VALUES FOR EACH MEASUREMENT
380  DATA 15,15,15,600E-3,600E-3,600E-3,30E-3,30E-3,30E-3,21E-3,21E-3,21E-3
390  !POWER SUPPLY VALUES FOR EACH MEASUREMENT
400  DATA 30,15,5,1.2,600E-3,200E-3,60E-3,30E-3,10E-3,42E-3,21E-3,7E-3
410  PRINT "PROGRAM COMPLETED"
420  END

```

4-13. Offset Accuracy Test Procedure

This test verifies offset accuracy.

1. Connect the equipment as shown below. Use a banana-to-BNC adapter to connect the BNC cable to the power supply. Set the power supply for 2.00 V output.

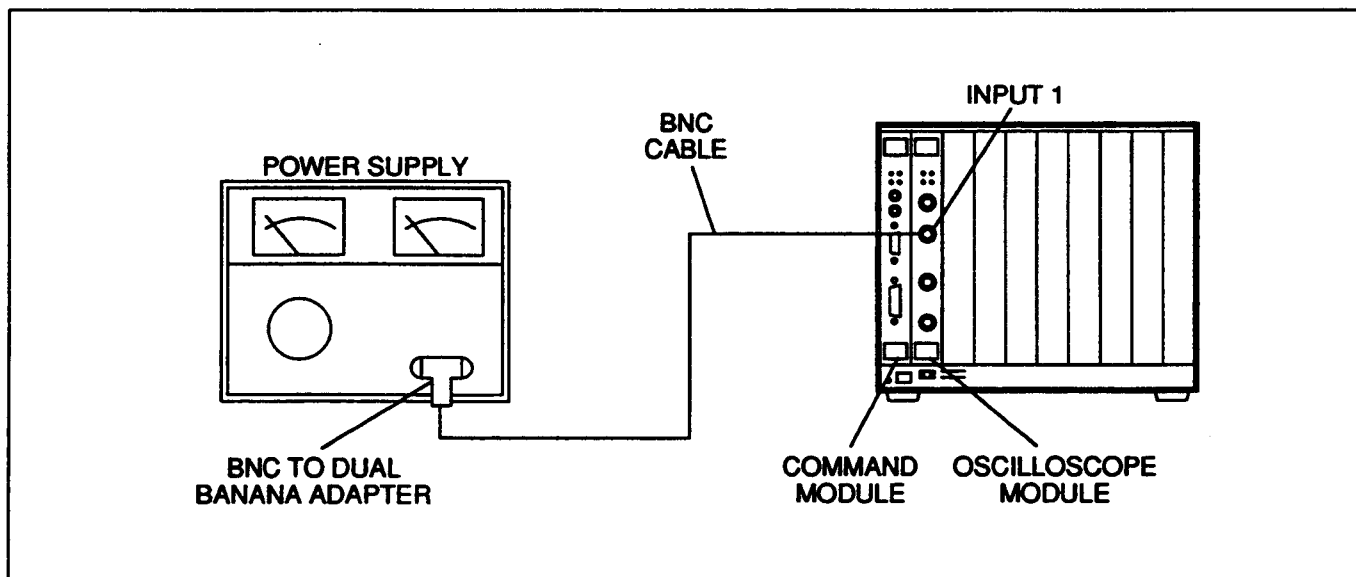


Figure 4-4. Offset Accuracy Test Set-up

2. Set the HP E1428A controls as follows:

```

Reset HP E1428A ..... *RST
Time base to automatic ..... TIM:MODE AUT
Timebase to repetitive ..... TIM:SAMP REP
Start data acquisition ..... RUN
Turn on channel 1 ..... VIEW CHAN1
Turn off unused channels ..... BLAN CHAN2
Channel 1 to DC at 1MΩ ..... CHAN1:COUP DC
Acquisition type to average ..... ACQ:TYP AVER
Acquisition count to 32 ..... ACQ:COUN 32
Channel 1 range to 1.6 V ..... CHAN1:RANG 1.6
Channel 1 offset to 2 V ..... CHAN1:OFFS 2
Measure channel 1 ..... MEAS:SOUR CHAN1
Digitize channel 1 ..... DIG CHAN1
Measure average voltage ..... MEAS:VAV?
  
```

3. Verify that average voltage as measured by the HP E1428A is between 1.948 V and 2.052 V.
4. Repeat steps 2 and 3 for all the HP E1428A RANGE and OFFSet values, and power supply voltages specified in the table below.

RANGe	OFFSet	Power Supply	Tolerance	Limits
1.6 V	2.0000 V	2.00 V	±52 mV	1.948 V to 2.052 V
800 mV	1.00000 V	1.00 V	±26 mV	0.974 V to 1.026 V
400 mV	500.000 mV	500 mV	±13 mV	487 mV to 513 mV

5. Repeat steps 2 through 4 for channel 2.

Notes

When repeating the procedure, all references to channel 1 should be changed to channel 2. Turn off unused channel using the BLANk command.

Offset errors can be caused by the need for self calibration. Perform vertical calibration, (see Adjustment procedures, Chapter 5) before troubleshooting instrument. If self-calibration fails to correct problem, cause may be the attenuator or PCA. See troubleshooting in Chapter 8.

6. Disconnect test equipment.

Example This program will automatically prompt the user through the steps required to perform an offset accuracy test, and print out the results of each measurement. The data at the end of the program corresponds to the values for range, offset and supply voltage in each measurement.

The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  !PROGRAM "OFFSATS"
20  !OFFSET ACCURACY TEST PROCEDURE
30  CLEAR SCREEN
40  PRINT "CONNECT POWER SUPPLY TO SCOPE INPUT 1"
50  PRINT "PRESS CONTINUE"
60  PAUSE
70  ASSIGN @Scope TO 70905      ! USE A VARIABLE FOR SCOPE ADDRESS
80  OPTION BASE 1
90  DIM Range(3),Offset(3),Power_supply(3)
100 RESTORE
110 READ Range(*),Offset(*),Power_supply(*)
120 OUTPUT @Scope;"*CLS"
130 OUTPUT @Scope;"*RST"
140 FOR Channel=1 TO 2
150     OUTPUT @Scope;"TIM:MODE AUTO"
160     OUTPUT @Scope;"RUN"
170     OUTPUT @Scope;"BLAN CHAN1,CHAN2"
180     OUTPUT @Scope;"VIEW CHAN"&VAL$(Channel)
190     OUTPUT @Scope;"CHAN"&VAL$(Channel)&":COUP DC"
200     OUTPUT @Scope;"TIMEBASE:SAMP REP"      ! FOR AVERAGING MUST BE REPETITIVE
210     OUTPUT @Scope;"ACQ:TYPE AVER"
220     OUTPUT @Scope;"ACQ:COUN 32"
230     PRINT "CONNECT THE POWER SUPPLY TO SCOPE CHANNEL "&VAL$(Channel)
240     FOR Measurement=1 TO 3
250         PRINT "SET THE POWER SUPPLY TO "&VAL$(Power_supply(Measurement))&" VOLTS"
260         PAUSE
270         OUTPUT @Scope;"CHAN"&VAL$(Channel)&":RANG "&VAL$(Range(Measurement))
280         OUTPUT @Scope;"CHAN"&VAL$(Channel)&":OFFS "&VAL$(Offset(Measurement))
290         OUTPUT @Scope;"MEAS:SOUR CHAN"&VAL$(Channel)
300         OUTPUT @Scope;"DIG CHAN"&VAL$(Channel)
310         OUTPUT @Scope;"MEAS:VAV?"
320         ENTER @Scope;Voltage_val
330         PRINT "RESULT = "&VAL$(Voltage_val)
340     NEXT Measurement
350 NEXT Channel
360 OUTPUT @Scope;"*RST"
370 DATA 1.6,800E-3,400E-3
380 DATA 2,1,500E-3
390 DATA 2,1,500E-3
400 PRINT "PROGRAM COMPLETED"
410 END

```

4-14. Bandwidth Test Procedure

This test checks the repetitive and real time bandwidths of the HP E1428A.

1. Connect the equipment as shown below. Use a type N cable to connect the signal generator to the power splitter input. Connect the power sensor to one output of the power splitter. Use an N-to-BNC adapter to connect the other power splitter output to the HP E1428A channel 1 input.

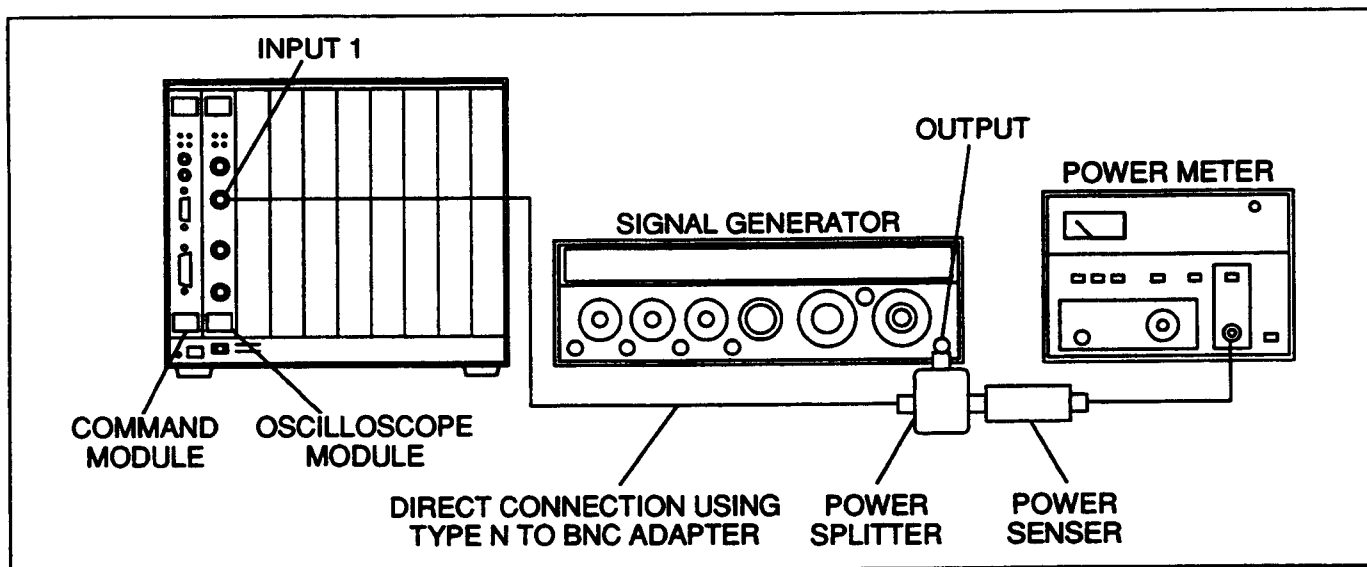


Figure 4-5. Bandwidth Test Set-up

2. Set the Signal Generator controls as follows:

Frequency	1 MHz
Output	-2.4 dBm

Note

Setting the output to -2.4 dBm will produce a -8.4 dBm level at the HP E1428A 50Ω input (loss occurs through the power splitter).

3. Set the HP E1428A controls as follows:

Reset HP E1428A	*RST
Time base to 2μsec	TIM:RANG 2E-6
Channel 1 to DC at 50Ω	CHAN1:COUP DCF
Trigger source to channel 1	TRIG:SOUR CHAN1
Time base sample to repetitive	TIM:SAMP REP
Acquisition type to average	ACQ:TYP AVER
Acquisition count to 32	ACQ:COUN 32
Channel 1 range to 320 mV	CHAN1:RANG 320E-3
Measure channel 1	MEAS:SOUR CHAN1
Digitize channel 1	DIG CHAN1
Measure peak-to-peak voltage	MEAS:VPP?

4. Record the measured peak-to-peak voltage.

V 1 MHz = _____.

5. Set the Power Meter controls as follows:

Press dB REF to set a 0 dB reference
Calibration Factor to power sensor 250 MHz value

6. Set the Signal Generator frequency to 250 MHz, then adjust the output level for a power meter reading as close as possible to 0.0 dB (REL). Record the reading.

Power Meter = _____.

7. Set the HP E1428A controls as follows:

Time base range to 20 nsec..... TIM:RANG 2E-8
Measure channel 1 MEAS:SOUR CHAN1
Digitize channel 1 DIG CHAN1
Measure peak-to-peak voltage MEAS:VPP?

8. Record the measured peak-to-peak voltage.

V 250 MHz = _____.

9. Calculate the response from the measured results in steps 4 and 8 using the following formula:

$$\text{response(dB)} = 20 \log_{10} \frac{V_{250\text{MHz}}}{V_{1\text{MHz}}} = 20 \log_{10} \frac{\quad}{\quad} = \quad \text{dB}$$

10. Correct the result in step 9 with any difference in the power meter reading from step 6 using the following formula. Observe signs.

$$(\text{step 9}) - (\text{step 6}) = \quad \text{dB}$$

For example:

Result from step 9 = -2.3 dB

Power meter reading = -0.2 dB(REL)

then true response = (-2.3)-(-0.2) = -2.1 dB

11. Verify the result in step 10 is ≤ -3.0 dB.
12. Connect the power splitter to channel 2, and repeat steps 2 through 12.

Notes

When repeating the procedure, all references to channel 1 should be changed to the channel being tested. Turn off unused channel using the BLANK command.

Bandwidth errors can be caused by the need for adjustment. Perform high frequency pulse response adjustment, (see Adjustment procedures, Chapter 5) before troubleshooting instrument. If adjustment fails to correct problem, cause may be the attenuator or PCA. See troubleshooting in Chapter 8.

13. Disconnect test equipment.

Example This program is provided to show how to perform a bandwidth test, and print out the results of each measurement. The program pauses to allow the user to adjust the signal generator and power meter.

The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPAtible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  !PROGRAM "BWTP"
20  !BANDWIDTH TEST PROCEDURE
30  CLEAR SCREEN
40  PRINT "CONNECT SIGNAL GENERATOR TO POWER SPLITTER"
50  PRINT "CONNECT POWER SPLITTER DIRECTLY TO SCOPE INPUT, NO CABLES"
60  PRINT "POWER METER TO POWER SPLITTER"
70  PRINT "SET SIGNAL GENERATOR, 1 MHz, -2.4dBm"
80  PRINT "PRESS CONTINUE"
90  PAUSE
100 ASSIGN @Scope TO 70905          ! USE A VARIABLE FOR SCOPE ADDRESS
110 OUTPUT @Scope;"*CLS"
120 OUTPUT @Scope;"*RST"
130 OUTPUT @Scope;"TIM:RANG 2E-6"
140 OUTPUT @Scope;"CHAN1:COUP DCF"
150 OUTPUT @Scope;"TRIG:SOUR CHAN1"
160 OUTPUT @Scope;"TIM:SAMP REP"
170 OUTPUT @Scope;"ACQ:TYPE AVER"
180 OUTPUT @Scope;"ACQ:COUN 32"
190 OUTPUT @Scope;"CHAN1:RANG 320E-3"
200 OUTPUT @Scope;"MEAS:SOUR CHAN1"
210 OUTPUT @Scope;"DIG CHAN1"
220 OUTPUT @Scope;"MEAS:VPP?"
230 ENTER @Scope;V_1mhz
240 PRINT V_1mhz,"MEASURED P-P VOLTAGE AT 1 MHz"
250 PRINT
260 PRINT "ADJUST SIGNAL GENERATOR AND POWER METER"
270 PRINT "SET SIGNAL GENERATOR TO 250 MHz, 0.0 dB"
280 PRINT "PRESS CONTINUE"
290 PAUSE
300 OUTPUT @Scope;"TIM:RANG 2E-8"
310 OUTPUT @Scope;"MEAS:SOUR CHAN1"
320 OUTPUT @Scope;"DIG CHAN1"
330 OUTPUT @Scope;"MEAS:VPP?"
340 ENTER @Scope;V_250mhz
350 PRINT V_250mhz, "MEASURED P-P VOLTAGE AT 250 MHz"
360 PRINT
370 PRINT "PRESS CONTINUE TO CALCULATE RESPONSE"
380 PAUSE
390 PRINT "CHANNEL RESPONSE =" ; 20*LGT(V_250mhz/V_1mhz) "
400 PRINT
410 PRINT "MAKE NECESSARY PROGRAM CHANGES AND REPEAT FOR CHANNEL 2"
420 PAUSE
430 PRINT "PROGRAM COMPLETED"
440 END

```

4-15. Time Measurement Accuracy Test Procedure

This test uses a precise frequency source to check the accuracy of time measurement functions.

1. Connect the equipment as shown below. Use an N-to-BNC adapter and BNC cable to connect the signal generator output to the HP E1428A channel 1 input.

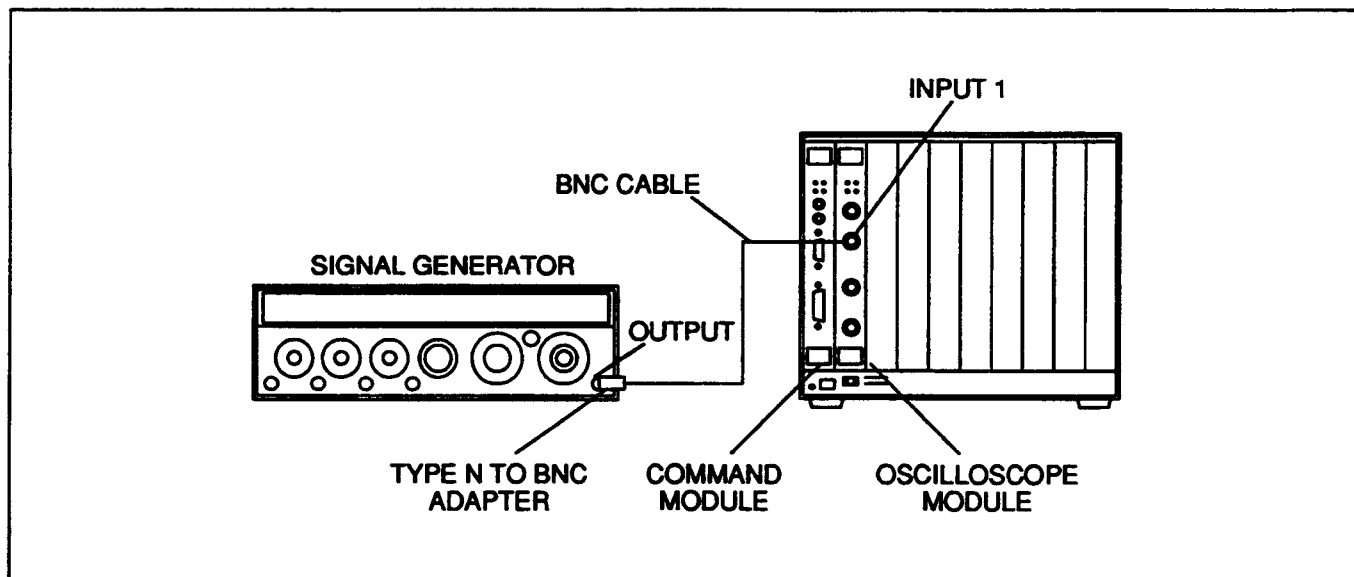


Figure 4-6. Time Measurement Accuracy Test Set-up in Repetitive Mode

2. Set the Signal Generator controls as follows:

Frequency	40 MHz
Output	0 dBm

3. Set the HP E1428A controls as follows:

Reset HP E1428A	*RST
Perform an autoscale	AUT
Timebase to repetitive	TIM:SAMP REP
Time base range to 500 nsec	TIM:RANG 5E-7
Time base delay to 0 sec	TIM:DEL 0
Channel 1 to DC at 50Ω	CHAN1:COUP DCF
Acquisition type to average	ACQ:TYP AVER
Acquisition count to 8	ACQ:COUN 8
Channel 1 range to 4 V	CHAN1:RANG 4
Measure channel 1	MEAS:SOUR CHAN1
Digitize channel 1	DIG CHAN1
Turn measurement statistics on	MEAS:MODE USER
Define delay conditions to measure from	
first positive edge midpoint to second positive edge	
midpoint	MEAS:DEF DEL,POS,1,MIDD,POS,2,MIDD
Measure delay	MEAS:DEL?

4. Verify that delay as measured by the HP E1428A is between 24.8988 ns and 25.1013 ns.
5. Set the HP E1428A controls as follows:
 - Define delay conditions to measure from
first positive edge midpoint to fifth positive edge
midpoint MEAS:DEF DEL,POS,1,MIDD,POS,5,MIDD
 - Measure channel 1 MEAS:SOUR CHAN1
 - Digitize channel 1 DIG CHAN1
 - Measure delayMEAS:DEL?
6. Verify that delay as measured by the HP E1428A is between 99.895 ns and 100.105 ns.
7. Set the HP E1428A controls as follows:
 - Define delay conditions to measure from
first positive edge midpoint to eleventh positive edge
midpoint MEAS:DEF DEL,POS,1,MIDD,POS,11,MIDD
 - Measure channel 1 MEAS:SOUR CHAN1
 - Digitize channel 1 DIG CHAN1
 - Measure delayMEAS:DEL?
8. Verify that delay as measured by the HP E1428A is between 249.8875 ns and 250.1125 ns.
9. Set the Signal Generator controls as follows:
 - Frequency 1 MHz (1.0 μ sec period)
 - Output 0 dBm
10. Set the HP E1428A controls as follows:
 - Time base range to 10 μ sec TIM:RANG 1E-5
 - Measure channel 1 MEAS:SOUR CHAN1
 - Digitize channel 1 DIG CHAN1
 - Define delay conditions to measure from
first positive edge midpoint to second positive edge
midpoint MEAS:DEF DEL,POS,1,MIDD,POS,2,MIDD
 - Measure delayMEAS:DEL?
11. Verify that delay as measured by the HP E1428A is between 996.95 μ s and 1.00305 μ s.
12. Set the HP E1428A controls as follows:
 - Define delay conditions to measure from
first positive edge midpoint to sixth positive edge
midpoint MEAS:DEF DEL,POS,1,MIDD,POS,6,MIDD
 - Measure channel 1 MEAS:SOUR CHAN1
 - Digitize channel 1 DIG CHAN1
 - Measure delayMEAS:DEL?
13. Verify that delay as measured by the HP E1428A is between 4.99675 μ s and 5.00325 μ s.

- Real-time Mode** 14. Connect the equipment as shown below. Use an N-to-BNC adapter and BNC cable to connect the signal generator output to the pulse generator EXT input. Use a BNC cable to connect the pulse generator output to the HP E1428A channel 1 input:

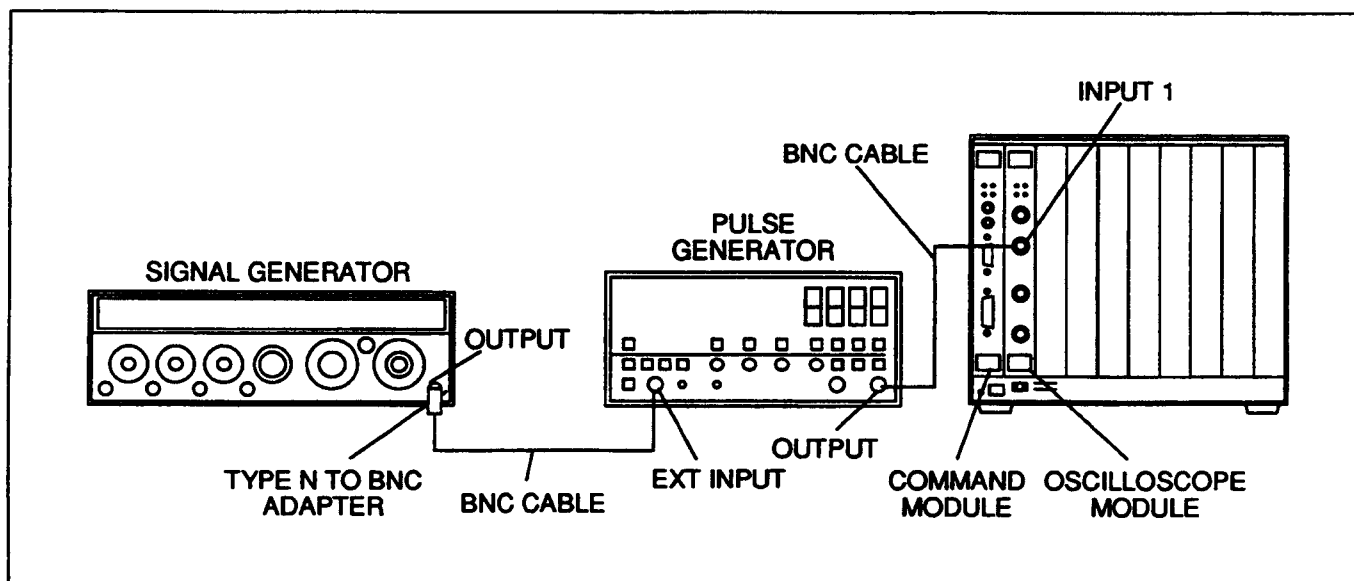


Figure 4-7. Time Measurement Accuracy Test Set-up in Real-time Mode

15. Set the Signal Generator controls as follows:

Frequency 25.31646 MHz (39.49999 ns period)
Output 800 mVrms

16. Set the Pulse Generator controls as follows:

Input mode TRIG
Width 12.5 nsec
Leading and Trailing Edge 1.3 nsec
High Level +0.14 V
Low Level -0.14V
Ext Input 50 Ω

17. Set the HP E1428A controls as follows:

Timebase to real-time TIM:SAMP REAL
Time base range to 500 nsec TIM:RANG 5E-7
Define delay conditions to measure from
first positive edge midpoint to eleventh positive edge
midpoint MEAS:DEF DEL,POS,1,MIDD,POS,11,MIDD
Measure channel 1 MEAS:SOUR CHAN1
Digitize channel 1 DIG CHAN1
Measure delay MEAS:DEL?

18. Verify that delay as measured by the HP E1428A is between 394.830 ns and 395.170 ns.

19. Set the HP E1428A controls as follows:

Measure channel 1 MEAS:SOUR CHAN1
Measure period MEAS:PER?

20. Verify that period as measured by the HP E1428A is between 39.348 ns and 39.652 ns.
21. Set the HP E1428A controls as follows:
 - Time base range to 500 nsec TIM:RANG 1E-5
 - Define delay conditions to measure from
 - first positive edge midpoint to 21st positive edge
 - midpoint MEAS:DEF DEL,POS,1,MIDD,POS,21,MIDD
 - Measure delayMEAS:DEL?
22. Verify that period as measured by the HP E1428A is between 3.94952 ns and 3.95025 ns.
23. Set the HP E1428A controls as follows:
 - Define delay conditions to measure from
 - first positive edge midpoint to 101st positive edge
 - midpointMEAS:DEF DEL,POS,1,MIDD,POS,101,MIDD
 - Measure delayMEAS:DEL?
24. Verify that period as measured by the HP E1428A is between 3.94952 ns and 3.95025 ns.
25. Disconnect test equipment.

Example This program will automatically prompt the user through the steps required to perform a time accuracy test, and print out the results of each measurement.

The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPAtible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  !PROGRAM "TMATP"
20  !TIME MEASUREMENT ACCURACY TEST PROCEDURE
30  CLEAR SCREEN
40  PRINT "CONNECT SIGNAL GENERATOR TO SCOPE INPUT 1"
50  PRINT "PRESS CONTINUE"
60  PAUSE
70  ASSIGN @Scope TO 70905          ! USE A VARIABLE FOR SCOPE ADDRESS
80  PRINT "REPETITIVE MODE TEST"
90  PRINT "SET SIGNAL GENERATOR TO 40 Mhz, 0 dBm.  When set, press Continue"
100 PAUSE
110 OUTPUT @Scope;"*CLS"
120 OUTPUT @Scope;"*RST"
130 OUTPUT @Scope;"AUT"
140 PRINT "AUTO DONE"
150 PRINT "PRESS CONTINUE"
160 PAUSE
170 OUTPUT @Scope;":TIM:SAMP REP"
180 OUTPUT @Scope;"TIM:RANG 5E-7"
190 OUTPUT @Scope;"TIM:DEL 0"
200 OUTPUT @Scope;"CHAN1:COUP DCF"
210 OUTPUT @Scope;"CHAN1:RANG 4"
220 OUTPUT @Scope;"ACQ:TYPE AVER"
230 OUTPUT @Scope;"ACQ:COUN 8"
240 OUTPUT @Scope;"MEAS:SOUR CHAN1"
250 OUTPUT @Scope;"DIG CHAN1"
260 OUTPUT @Scope;"MEAS:MODE USER"
270 OUTPUT @Scope;"MEAS:DEF DEL,POS,1,MIDD,POS,2,MIDD"
280 OUTPUT @Scope;"MEAS:DEL?"
290 ENTER @Scope;A
300 PRINT A, "DELAY BETWEEN 1 AND 2 PULSES"
310 OUTPUT @Scope;"MEAS:DEF DEL,POS,1,MIDD,POS,5,MIDD"
320 OUTPUT @Scope;"MEAS:SOUR CHAN1"
330 OUTPUT @Scope;"DIG CHAN1"
340 OUTPUT @Scope;"MEAS:DEL?"
350 ENTER @Scope;B
360 PRINT B, "DELAY BETWEEN 1 AND 5 PULSES"
370 OUTPUT @Scope;"MEAS:DEF DEL,POS,1,MIDD,POS,11,MIDD"
380 OUTPUT @Scope;"MEAS:SOUR CHAN1"
390 OUTPUT @Scope;"DIG CHAN1"

```

```

400 OUTPUT @Scope;"MEAS:DEL?"
410 ENTER @Scope;C
420 PRINT C, "DELAY BETWEEN 1 AND 11 PULSES"
430 PRINT "SET SIG GEN TO 1Mhz (1 uSEC PERIOD). "
440 PRINT "PRESS CONTINUE"
450 PAUSE ! TO SET SIG GEN TO 1MHZ (1 uSEC PERIOD)
460 OUTPUT @Scope;"TIM:RANG 1E-5"
470 OUTPUT @Scope;"MEAS:SOUR CHAN1"
480 OUTPUT @Scope;"DIG CHAN1"
490 OUTPUT @Scope;"MEAS:DEF DEL, POS,1,MIDD,POS,2,MIDD"
500 OUTPUT @Scope;"MEAS:DEL?"
510 ENTER @Scope;D
520 PRINT D, "DELAY AT 1MHZ BETWEEN 1 AND 2 PULSES"
530 OUTPUT @Scope;"MEAS:DEF DEL,POS,1,MIDD,POS,6,MIDD"
540 OUTPUT @Scope;"MEAS:SOUR CHAN1"
550 OUTPUT @Scope;"DIG CHAN1"
560 OUTPUT @Scope;"MEAS:DEL?"
570 ENTER @Scope;E
580 PRINT E, "DELAY BETWEEN 1 AND 6 PULSES"
590 PRINT
600 PRINT "CONNECT SIGNAL GENERATOR TO PULSE GENERATOR"
610 PRINT "CONNECT PULSE GENERATOR TO SCOPE INPUT 1"
620 PRINT "ADJUST SIGNAL GENERATOR TO 25.31646 MHZ, (39.49999 ns Period)"
630 PRINT "ADJUST SIGNAL GENERATOR OUTPUT TO 800 mVrms"
640 PRINT "ADJUST PULSE GENERATOR PER MANUAL"
650 PRINT "PRESS CONTINUE"
660 PAUSE
670 PRINT "REAL TIME TEST MODE"
680 OUTPUT @Scope;":TIM:RANG 5E-7"
690 OUTPUT @Scope;":TIM:SAMP REAL"
700 OUTPUT @Scope;"MEAS:DEF DEL,POS,1,MIDD,POS,11,MIDD"
710 OUTPUT @Scope;"MEAS:SOUR CHAN1"
720 OUTPUT @Scope;"DIG CHAN1"
730 OUTPUT @Scope;"MEAS:DEL?"
740 ENTER @Scope;F
750 PRINT F, "DELAY BETWEEN 1 AND 11"
760 OUTPUT @Scope;"MEAS:SOUR CHAN1"
770 OUTPUT @Scope;"MEAS:PER?"
780 ENTER @Scope;G
790 PRINT G, "SEC = PERIOD"
810 OUTPUT @Scope;"TIM:RANG 1E-5"
840 OUTPUT @Scope;"MEAS:DEF DEL,POS,1,MIDD,POS,21,MIDD"
880 OUTPUT @Scope;"MEAS:DEL?"
890 ENTER @Scope;H
900 PRINT H, "DELAY BETWEEN 1 AND 21 PULSES"
910 OUTPUT @Scope;"MEAS:DEF DEL,POS,1,MIDD,POS,101,MIDD"
920 OUTPUT @Scope;"MEAS:DEL?"
930 ENTER @Scope;I
940 PRINT I, "DELAY BETWEEN 1 AND 101 PULSES"
950 PRINT "PROGRAM COMPLETED"
960 END

```


4-16. Trigger Sensitivity Test Procedure

This test checks channel and external triggers for sensitivity at rated bandwidth.

1. Connect the equipment as shown below. Use an N-to-BNC adapter and BNC cable to connect the signal generator output to the HP E1428A channel 1 input.

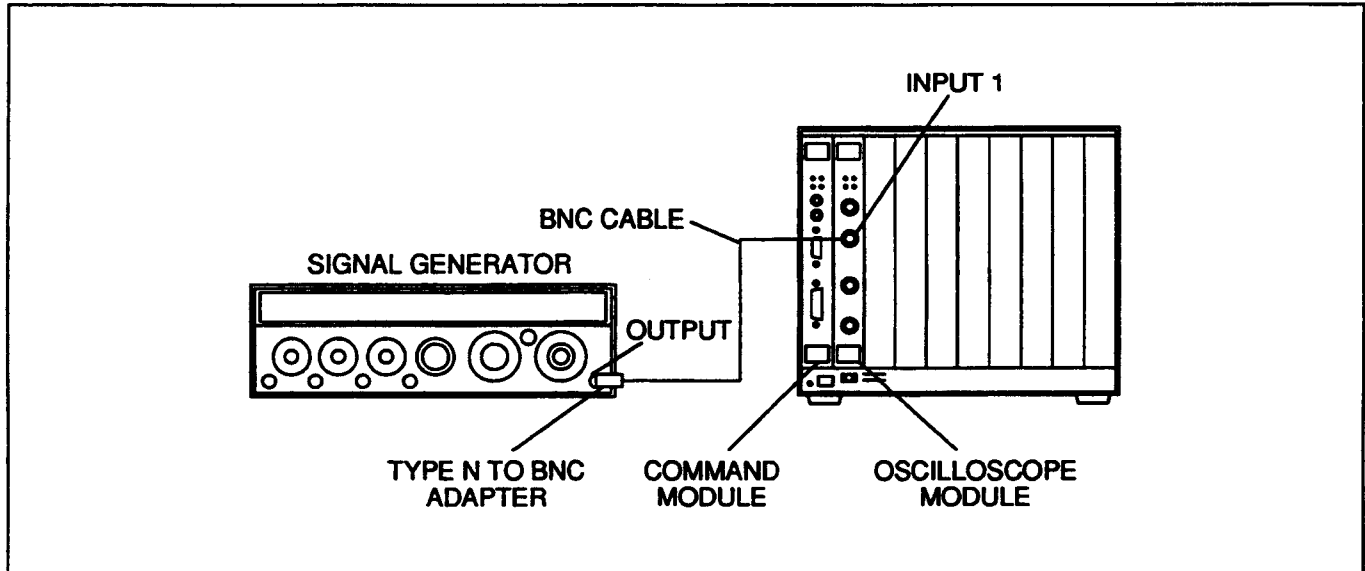


Figure 4-8. Internal Trigger Sensitivity Test Set-up

Internal Trigger

2. Set the Signal Generator controls as follows:

Frequency 100 MHz
Output 100 mVp-p

3. Set the HP E1428A controls as follows:

Reset HP E1428A *RST
Timebase to repetitive TIM:SAMP REP
Time base range to 50ns nsec TIM:RANG 5E-8
Turn on channel 1 VIEW CHAN1
Turn off unused channel BLAN CHAN2
Channel 1 to DC at 50Ω CHAN1:COUP DCF
Channel 1 range to 1.6 V CHAN1:RANG 1.6
Acquisition type to average ACQ:TYP AVER
Acquisition count to 16 ACQ:COUN 16
Trigger source to channel 1 TRIG:SOUR CHAN1
Trigger level to 0 V TRIG:LEV 0
Start HP E1428A running RUN

4. On the HP E1428A front panel, verify TRIGGERED LED is ON.

5. Set the Signal Generator controls as follows:

Frequency 250 MHz
Output 200 mV p-p

6. Set the HP E1428A controls as follows:

Time base to 20 nsec TIM:RANG 20E-9
 Start HP E1428A running RUN

7. On the HP E1428A front panel, verify TRIGGERED LED is ON.
8. Connect the signal generator output to channel 2, and repeat steps 2 through 7.

Notes

When repeating the procedure, all references to channel 1 should be changed to channel 2. Turn off unused channel using the BLANK command.

External Trigger

9. Connect the equipment as shown below. Use a type N cable to connect the signal generator to the power splitter input. Connect the power sensor to one output of the power splitter. Use an N-to-BNC adapter to connect the other power splitter output to the HP E1428A channel 1 input.

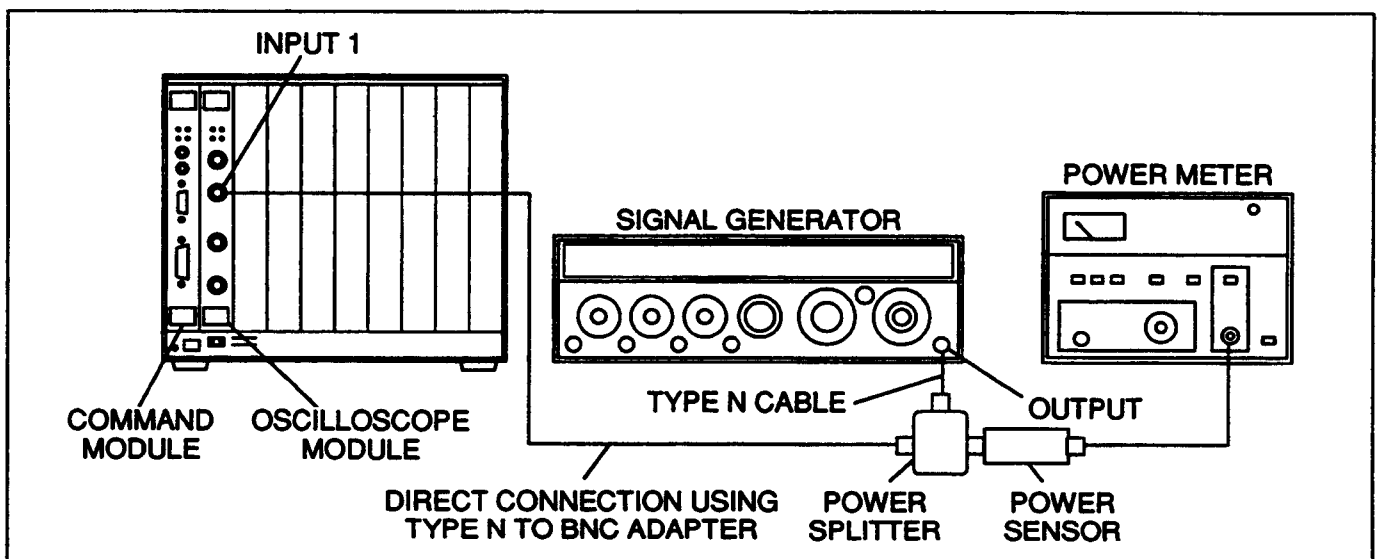


Figure 4-9. External Trigger Sensitivity Test Set-up

10. Set the Power Meter controls as follows:
 Press dB REF to set a 0 dB reference
 Calibration Factor to power sensor 250 MHz value
11. Set the Signal Generator controls as follows:
 Frequency 250 MHz
 Output for 25 μ W reading on Power Meter
12. Disconnect Power Sensor from the power splitter, and connect the output of the power splitter to the oscilloscope TRIGGER input.

13. Set the HP E1428A controls as follows:

Turn on channel 1 VIEW CHAN1
Turn off unused channel BLAN CHAN2
Channel 1 to DC at 50 Ω CHAN1:COUP DCF
Trigger coupling to DC at 50 Ω TRIG:COUP DCF
Trigger source to external TRIG:SOUR EXT
Trigger level to 0 V TRIG:LEV 0
Start HP E1428A running RUN

14. On the HP E1428A front panel, verify TRIGGERED LED is ON.

15. Repeat steps 9 through 14 for channel 2.

Notes

When repeating the procedure, all references to channel 1 should be changed to channel 2. Turn off unused channel using the BLANK command.

Trigger errors can be caused by the attenuator or PCA. See troubleshooting in Chapter 8.

16. Disconnect test equipment.

Example

This program will automatically prompt the user through the steps required to perform a trigger sensitivity test.

The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the HP E1428A
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```
10  !PROGRAM "TSTP"
20  !TRIGGER SENSITIVITY TEST PROCEDURE
30  CLEAR SCREEN
40  ASSIGN @Scope TO 70905          ! USE A VARIABLE FOR SCOPE ADDRESS
50  OUTPUT @Scope;"*CLS"
60  OUTPUT @Scope;"*RST"
70  FOR Channel=1 TO 2
80      PRINT "CONNECT THE SIGNAL GENERATOR TO SCOPE CHANNEL "&VAL$(Channel)
90      PRINT "SET THE SIGNAL GENERATOR TO 100 MHz AND 100 mVp-p"
100     PRINT "PRESS CONTINUE"
110     PAUSE
120     OUTPUT @Scope;"TIM:RANG 5E-8"
130     OUTPUT @Scope;"BLAN CHAN1,CHAN2"
140     OUTPUT @Scope;"VIEW CHAN"&VAL$(Channel)
150     OUTPUT @Scope;"CHAN"&VAL$(Channel)&":COUP DCF"
160     OUTPUT @Scope;"CHAN"&VAL$(Channel)&":RANG 1.6"
170     OUTPUT @Scope;"TIM:SAMP REP"
180     OUTPUT @Scope;"ACQ;TYPE AVER"
190     OUTPUT @Scope;"ACQ:COUN 16"
200     OUTPUT @Scope;"TRIG:SOUR CHAN"&VAL$(Channel)
210     OUTPUT @Scope;"TRIG:LEV 0"
```

```

220     OUTPUT @Scope;"RUN"
230     PRINT "TRIGGERED?  OBSERVE TRIG'D LED"
240     PRINT "PRESS CONTINUE"
250     PAUSE
260     PRINT "SET THE SIGNAL GENERATOR TO 250 MHz AND 200 mVp-p"
270     PRINT "PRESS CONTINUE"
280     PAUSE
290     OUTPUT @Scope;"TIM:RANG 20E-9"
300     OUTPUT @Scope;"RUN"
310     PRINT "TRIGGERED?  OBSERVE TRIG'D LED"
320     PRINT "PRESS CONTINUE"
330     PAUSE
340 NEXT Channel
350 FOR Channel=1 TO 2
360     PRINT "CONNECT THE SIGNAL GENERATOR (USING POWER SPLITTER) TO POWER METER AND SCOPE
        CHANNEL "&VAL$(Channel)
370     PRINT "PRESS CONTINUE"
380     PAUSE
390     PRINT "ZERO POWER METER/SENSOR AND ENTER SENSOR'S 250 MHz CAL FACTOR."
400     PRINT "SET THE SIGNAL GENERATOR TO 250 MHz AND ADJUST OUTPUT"
410     PRINT "UNTIL POWER METER READS 25 uW"
420     PRINT "PRESS CONTINUE"
430     PAUSE
440     PRINT "DISCONNECT POWER SENSOR, AND RECONNECT POWER SPLITTER TO SCOPE'S EXT TRIGGER
        INPUT"
450     OUTPUT @Scope;"BLAN CHAN1,CHAN2"
460     OUTPUT @Scope;"VIEW CHAN"&VAL$(Channel)
470     OUTPUT @Scope;"CHAN"&VAL$(Channel)&":COUP DCF"
480     OUTPUT @Scope;"TRIG:COUP DCF"
490     OUTPUT @Scope;"TRIG:SOUR EXT"
500     OUTPUT @Scope;"TRIG:LEV 0"
510     OUTPUT @Scope;"RUN"
520     PRINT "TRIGGERED?  OBSERVE TRIG'D LED"
530     PRINT "PRESS CONTINUE"
540     PAUSE
550 NEXT Channel
560 OUTPUT @Scope;"*RST"
570 PRINT "PROGRAM COMPLETED"
580 END

```

Table 4-1. Verification Test Record

Hewlett-Packard Company				
Model HP E1428A		Tested by _____		
C Size VXI Oscilloscope Module		Work Order No. _____		
√ Recommended test interval [] 6 months [] 1000 hours		Recommended next testing _____		
Serial Number _____		Temperature _____	Date _____	

Para- No.	Test	Min.	Results Actual	Max.
4-7	FUNCTIONAL VERIFICATION Self Test Test passes (+0 returned)		[√] _____	
	PERFORMANCE VERIFICATION			
4-10	DC Calibrator Test Calculated Difference (0 and 5 V)	4.990 Vdc	_____	5.010 Vdc
4-11	Input Resistance Test			
	CHAN 1			
	1MΩ	990 kΩ	_____	1.010 MΩ
	50Ω	49.50Ω	_____	50.50Ω
	CHAN 2			
	1MΩ	990 kΩ	_____	1.010 MΩ
	50Ω	49.50Ω	_____	50.50Ω
4-12	Voltage Measurement Accuracy Test			
	CHAN 1			
	40 V Range, 30 V Power Supply	29.34 V	_____	30.66 V
	40 V Range, 15 V Power Supply	14.34 V	_____	15.66 V
	40 V Range, 5 V Power Supply	4.34 V	_____	5.66 V
	1.6 V Range, 1.2 V Power Supply	1.1736 mV	_____	1.2264 mV
	1.6 V Range, 600 mV Power Supply	573.6 mV	_____	626.4 mV
	1.6 V Range, 200 mV Power Supply	173.6 mV	_____	226.4 mV
	80 mV Range, 60 mV Power Supply	58.68 mV	_____	61.32 mV
	80 mV Range, 30 mV Power Supply	28.68 mV	_____	31.32 mV
	80 mV Range, 10 mV Power Supply	8.68 mV	_____	11.32 mV
	56 mV Range, 42 mV Power Supply	41.076 mV	_____	42.924 mV
	56 mV Range, 21 mV Power Supply	20.076 mV	_____	21.924 mV
	56 mV Range, 7 mV Power Supply	6.076 mV	_____	7.924 mV

Table 4-1. Verification Test Record — Continued

Para- No.	Test	Min.	Results Actual	Max.
4-12	PERFORMANCE VERIFICATION — Continued			
	Voltage Measurement Accuracy Test — Cont			
	CHAN 2			
	40 V Range, 30 V Power Supply	29.34 V	_____	30.66 V
	40 V Range, 15 V Power Supply	14.34 V	_____	15.66 V
	40 V Range, 5 V Power Supply	4.34 V	_____	5.66 V
	1.6 V Range, 1.2 V Power Supply	1.1736 mV	_____	1.2264 mV
	1.6 V Range, 600 mV Power Supply	573.6 mV	_____	626.4 mV
	1.6 V Range, 200 mV Power Supply	173.6 mV	_____	226.4 mV
	80 mV Range, 60 mV Power Supply	58.68 mV	_____	61.32 mV
	80 mV Range, 30 mV Power Supply	28.68 mV	_____	31.32 mV
	80 mV Range, 10 mV Power Supply	8.68 mV	_____	11.32 mV
	56 mV Range, 42 mV Power Supply	41.076 mV	_____	42.924 mV
	56 mV Range, 21 mV Power Supply	20.076 mV	_____	21.924 mV
	56 mV Range, 7 mV Power Supply	6.076 mV	_____	7.924 mV
4-13	Offset Accuracy Test			
	CHAN 1			
	1.6 V Range, 2 V Offset	1.948 V	_____	2.052 V
	800 mV Range, 1 V Offset	0.974 V	_____	1.026 V
	400 mV Range, 500 mV Offset	487 mV	_____	513 mV
	CHAN 2			
	1.6 V Range, 2 V Offset	1.948 V	_____	2.052 V
	800 mV Range, 1 V Offset	0.974 V	_____	1.026 V
	400 mV Range, 500 mV Offset	487 mV	_____	513 mV
4-14	Bandwidth Test			
	CHAN 1			
	≥80 mV Full Scale Range at 250 MHz	≤-3.0 dB	_____	
4-15	CHAN 2			
	≥80 mV Full Scale Range at 250 MHz	≤-3.0 dB	_____	
4-15	Time Measurement Accuracy Test			
	Repetitive Mode			
	25 nsec	24.8988 ns	_____	25.1013 ns
	100 nsec	99.895 ns	_____	100.105 ns
	250 nsec	249.8875 ns	_____	250.1125 ns
	1 μsec	996.95 ns	_____	1.00305 μs
	5.0 μsec	4.99675 μsec	_____	5.00325 μs
	Realtime Mode			
	Delay 395 ns	394.830 ns	_____	395.170 ns
	Period 39.5 ns	39.348 ns	_____	39.652 ns
	Delay 3.949999 μs	3.94952 μs	_____	3.95025 μs

Table 4-1. Verification Test Record — Continued

Para- No.	Test	Min.	Results Actual	Max.
4-16	Trigger Sensitivity Test			
	CHAN 1			
	INT at 100 MHz		[✓] _____	
	INT at 250 MHz		[✓] _____	
	EXT at 250 MHz		[✓] _____	
	CHAN 2			
	INT at 100 MHz		[✓] _____	
	INT at 250 MHz		[✓] _____	
	EXT at 250 MHz		[✓] _____	

Adjustments

5-1. Introduction

This chapter contains adjustments that assure peak performance of the HP E1428A Oscilloscope. This instrument should be adjusted after repair to assure performance.

Some Oscilloscope adjustments are performed electrically, meaning a manual adjustment on a particular component is not necessary. The order in which the adjustments are made is critical. Perform adjustments in the order given.

Note

To consider the tests valid, the following conditions must be met:

- The Oscilloscope must have a 30 minute warm-up at ambient temperature installed in the mainframe.
 - The line voltage must be 115/230 Vac $\pm 10\%$.
 - For greatest accuracy, the temperature of the test area should be between 18°C and 28°C and should be stable within $\pm 1^\circ\text{C}$.
-

5-2. Equipment Required

Equipment required for the adjustment procedures is listed in Table 1-1, Recommended Test Equipment. Any equipment that satisfies the critical specifications given in the table may be substituted.

Caution

Do not remove the module with power applied to the mainframe.

The firmware calibration procedures should only be performed after the instrument has run for one half hour at ambient temperature installed in the mainframe.

Notes

All firmware calibration/adjustment procedures should be done in the order given.

After calibrating, you **MUST** perform an AUToscale or *RST (reset) to return to normal operation.

5-3. Load Default Calibration Procedure

The default calibration factors are loaded to give a known base for the following hardware and firmware calibration procedures.

Caution

Once the default cals are loaded, all firmware calibrations must be done. This includes vertical, delay, time null, logic trigger delay, and external trigger null calibrations.

All calibration must be performed in the order given.

1. Set the Oscilloscope controls as follows:

Non-volatile RAM unprotect.... SYST:NVPR OFF,<password>
Select Default Cal routine CAL:SCAL:DCAL
Load Default Cal data CAL:SCAL:BCAL
Clear status register *CLS
Reset oscilloscope *RST
Preset oscilloscope SUMM:PRES

Note

If R208 (CAL PROTECT) is installed (on top of the board towards the front), then the Non-volatile RAM is always in the unprotect mode, and sending the SYST:NVPR OFF,<password> command is not necessary. <password> default is "SYSTEM" from factory.

Example

The following example shows how to perform a default calibration load. The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the Oscilloscope
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```
10 !PROGRAM "LOCALP"
20 !LOAD DEFAULT CALIBRATION PROCEDURE
30 CLEAR SCREEN
40 ASSIGN @Scope TO 70905 ! USE A VARIABLE FOR SCOPE ADDRESS
50 PRINT "DEFAULT CALIBRATION FACTORS WILL BE LOADED."
60 PRINT "PRESS CONTINUE TO GO ON OR SHIFT/RESET TO TERMINATE PROGRAM."
70 PAUSE
80 CLEAR SCREEN
90 OUTPUT @Scope;"SYST:NVPR OFF,'SYSTEM'"
100 PRINT "CALIBRATION SWITCH TO UNPROTECTED"
110 OUTPUT @Scope;"CAL:SCAL:DCAL"
120 PRINT "DEFAULT CALIBRATION ROUTINE SELECTED"
130 OUTPUT @Scope;"CAL:SCAL:BCAL"
140 PRINT "DEFAULT CALIBRATION DATA LOADED"
150 OUTPUT @Scope;"*CLS"
160 PRINT "CLEAR STATUS"
170 OUTPUT @Scope;"*RST"
180 PRINT "OSCILLOSCOPE RESET TO DEFAULT STATE"
190 OUTPUT @Scope;"SUMM:PRES"
200 PRINT "OSCILLOSCOPE PRESET"
210 PRINT "PROGRAM COMPLETED"
220 END
```

5-4. Firmware Calibration Procedure

Firmware calibration uses signals generated in the oscilloscope (available at the Probe Comp/Cal/Trig Output connector) to calibrate channel sensitivity, offsets, and trigger parameters.

Caution

The Firmware Calibration should only be done after the oscilloscope has been installed and running in the VXI mainframe for one half hour at ambient temperature with all covers installed.

Note

The "Load Default Calibration Procedure" must be completed prior to performing the Firmware Calibration Procedure..

Vertical Calibration

1. Connect the Oscilloscope Probe Comp/Cal/Trig Output connector to the Input 1, Input 2, and EXT TRIG connectors using a BNC Tee and cables.

Note

Verify that the BNC cables are not longer than 1 meter and same length.

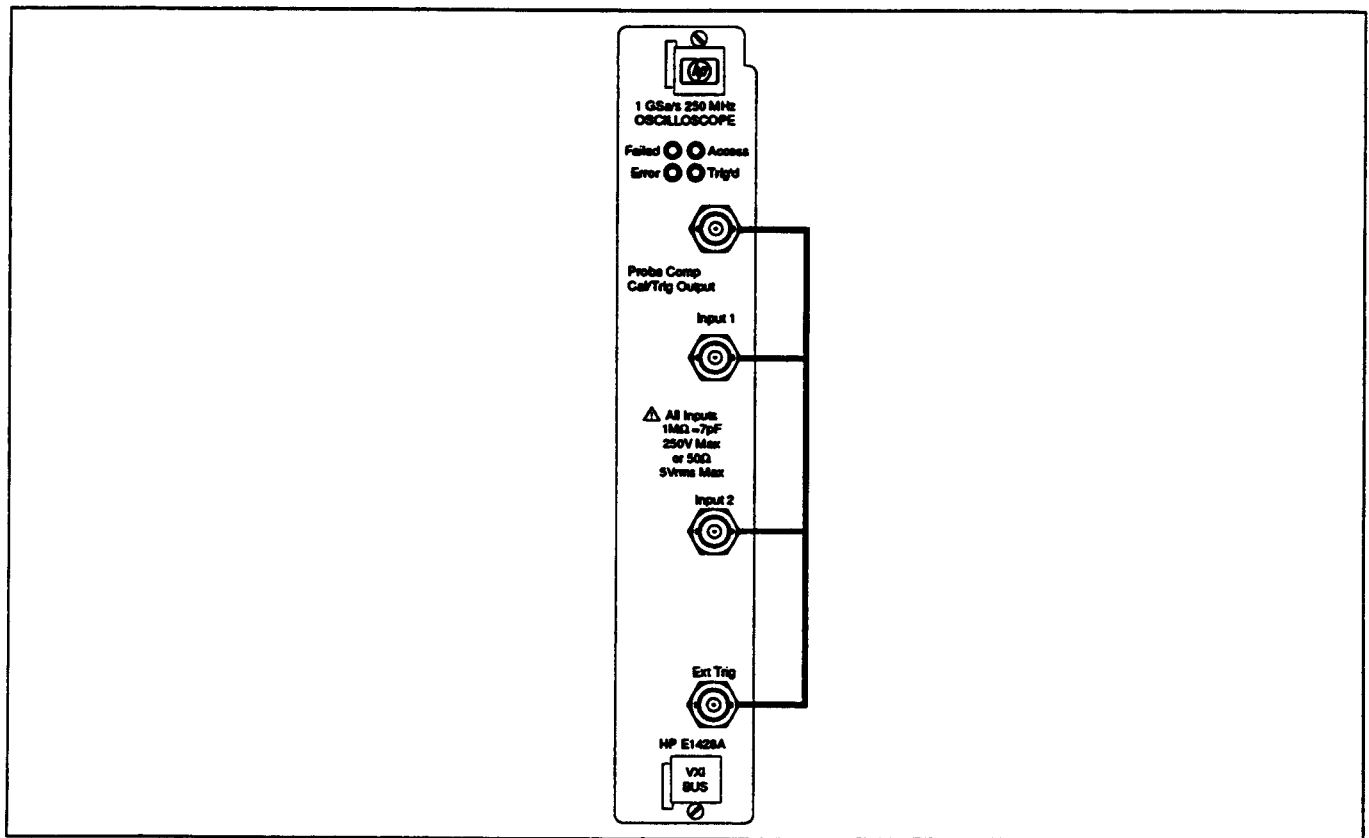


Figure 5-1. Example: Vertical Calibration Setup

2. Perform clear status, reset, then preset the Oscilloscope.
3. Select and start the vertical calibration routine. Calibration will last for no longer than 15 minutes. During calibration, the access and error LED's will be on.

Note

If the calibration time exceeds 15 minutes, the calibration is invalid. Recycle power then repeat procedure. If the condition repeats, the instrument is malfunctioning. Refer to Chapter 8 for information on correcting the malfunction before proceeding.

4. After calibration is complete (LED's to off), read the calibration event register to verify that no errors were generated during the procedure.
 - If "0" is returned, the calibration was successful.
 - If "0" is not returned, the calibration attempt was unsuccessful. See Chapter 4, CALibrate Subsystem in the User's manual for more information.
5. When complete, disconnect BNC cables and BNC Tee, and perform Delay Calibration Procedure.

Example

The following example shows how to perform a vertical calibration. The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the Oscilloscope
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  !PROGRAM "FCALP"
20  !FIRMWARE CALIBRATION PROCEDURE
30  CLEAR SCREEN
40  ASSIGN @Scope TO 70905      ! USE A VARIABLE FOR SCOPE ADDRESS
50  PRINT "CONNECT PROBE COMP CAL/TRIG OUTPUT CONNECTOR"
60  PRINT "TO INPUT 1, INPUT 2, AND EXT TRIG"
70  PRINT "PRESS CONTINUE"
80  PAUSE
90  OUTPUT @Scope;"*CLS"
100 OUTPUT @Scope;"*RST"
110 OUTPUT @Scope;"SUMM:PRES"
120 OUTPUT @Scope;"CAL:SCAL:VERT"
140 OUTPUT @Scope;"CAL:SCAL:BCAL"
160 OUTPUT @Scope;"SUMM:QUES:CAL?"
170 PRINT "CALIBRATION TAKES APPROXIMATELY 4 MINUTES TO COMPLETE."
180 PRINT "ERROR LIGHT WILL BE ON DURING CAL."
190 ENTER @Scope;A
200 PRINT A,"CALIBRATION RESULTS"
210 PRINT "PROGRAM COMPLETED"
220 END

```

Delay Calibration

6. Connect the Oscilloscope Probe Comp/Cal/Trig Output connector to the Input 1 connector using a BNC cable.

Note

Verify that the BNC cable is not longer than 1 meter.

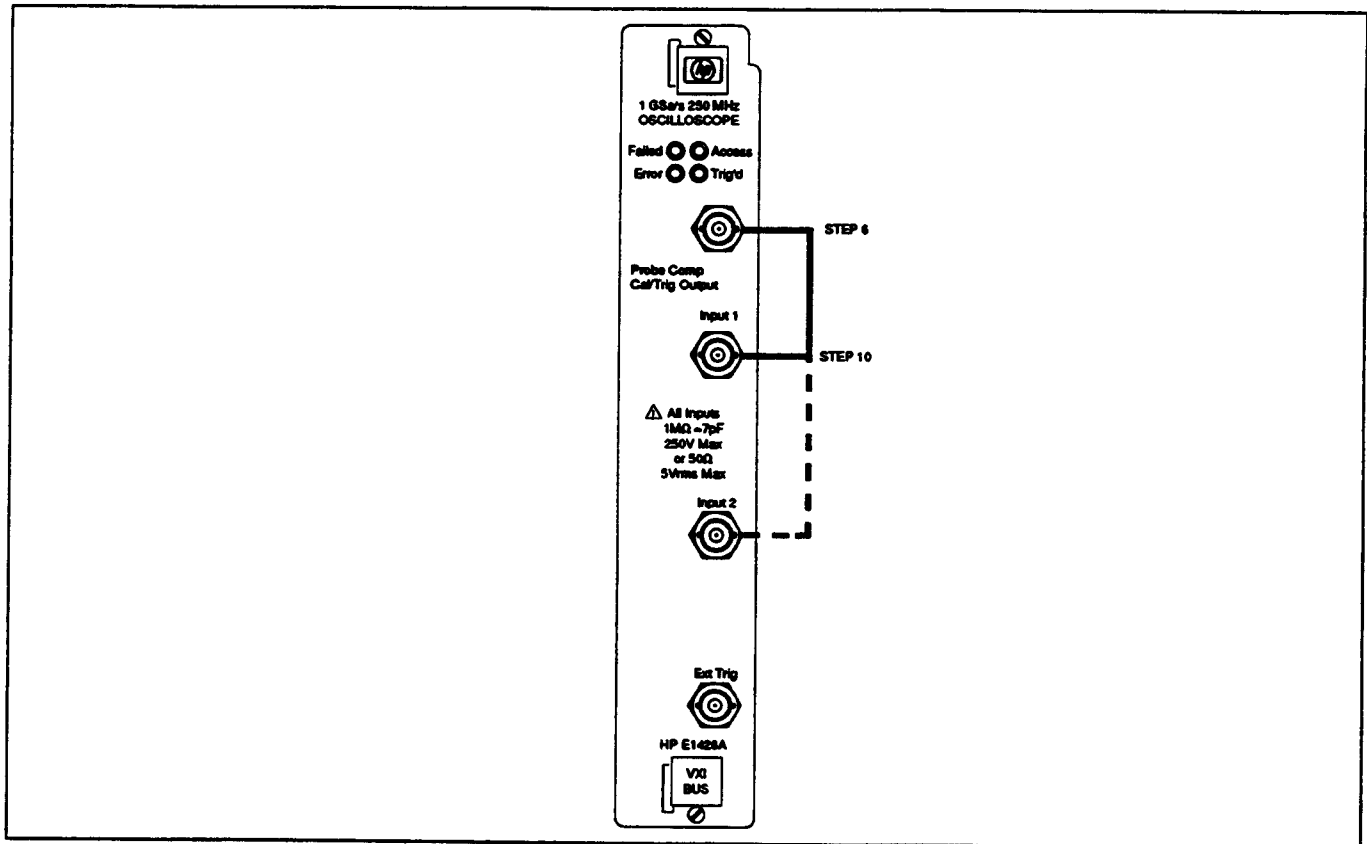


Figure 5-2. Example: Delay Calibration Setup

7. Perform clear status, reset, then preset the Oscilloscope.
8. Select and start the delay calibration routine. During calibration, the access and error LED's will be on.

Note

If the calibration time exceeds 1 minute, the calibration is invalid. Recycle power then repeat procedure. If the condition repeats the instrument is malfunctioning. Refer to the Chapter 8 for information on correcting the malfunction before proceeding.

9. After calibration is complete (LED's to off), read the calibration event register to verify that no errors were generated during the procedure.
 - If "0" is returned, the calibration was successful.
 - If "0" is not returned, the calibration attempt was unsuccessful. See Chapter 4, CALibrate Subsystem in the User's manual for more information.
10. Disconnect cable from input 1 and reconnect to input 2. Repeat steps 8 and 9 for input 2.
11. When complete, disconnect BNC cable and perform Time Null Calibration Procedure.

Example The following example shows how to perform a delay calibration. The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the Oscilloscope
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  !PROGRAM "DELCAL"
20  !DELAY CALIBRATION
30  CLEAR SCREEN
40  PRINT "WARNING:  If E1428A is improperly connected to generator"
50  PRINT "           or if hardware is defective, calibration will"
60  PRINT "           not complete but will TIMEOUT after 3 minutes."
70  PRINT
80  PRINT "           If program is not allowed to run, power to E1428A"
90  PRINT "           must be cycled for further communication with scope."
100 PRINT
110 ASSIGN @Scope TO 70905      ! USE A VARIABLE FOR SCOPE ADDRESS
120 OUTPUT @Scope;"**CLS"
130 OUTPUT @Scope;"**RST"
140 OUTPUT @Scope;"SUMM:PRES"
150 PRINT "CONNECT PROBE COMP CAL/TRIG TO INPUT 1"
160 PRINT "PRESS CONTINUE"
170 PAUSE
180 FOR I=1 TO 2
190 OUTPUT @Scope;"CAL:SCAL:DEL CHAN"&VAL$(I)
200 OUTPUT @Scope;"CAL:SCAL:BCAL"
210 OUTPUT @Scope;"SUMM:QUES:CAL?"
220 PRINT "CALIBRATION TAKES LESS THAN 1 MINUTE."
230 PRINT "ERROR LIGHT WILL BE ON DURING CAL."
240 ENTER @Scope;B
250 PRINT B,"CALIBRATION RESULTS FOR CHANNEL ";I
260 IF I=2 THEN GOTO 310
270 PRINT "CONNECT PROBE COMP CAL/TRIG OUTPUT TO INPUT 2"
280 PRINT "PRESS CONTINUE"
290 PAUSE
300 NEXT I
310 PRINT "PROGRAM COMPLETED"
320 END

```

Time Null Calibration

12. Connect the Oscilloscope Probe Comp/Cal/Trig Output connector to the Input 1 and Input 2 connectors using a BNC Tee.

Note

Verify that the BNC cables are not longer than 1 meter and equal in length.

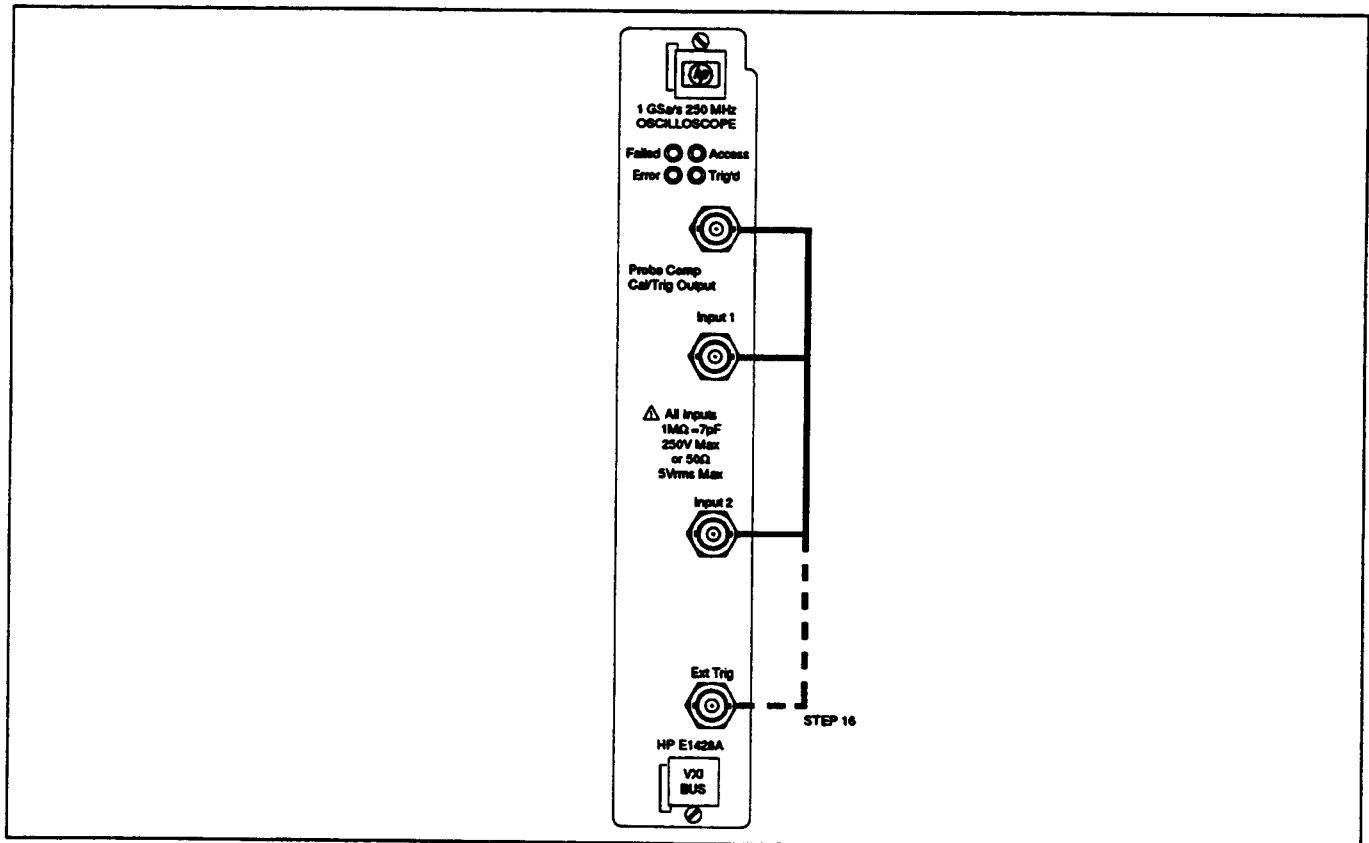


Figure 5-3. Example: Time Null Calibration Setup

13. Perform clear status, reset, then preset the Oscilloscope.
14. Select and start the time null calibration routine. During calibration, the access and error LED's will be on.

Note

If the calibration time exceeds 1 minute, the calibration is invalid. Recycle power then repeat procedure. If the condition repeats the instrument is malfunctioning. Refer to Chapter 8 for information on correcting the malfunction before proceeding.

15. After calibration is complete (LED's to off), read the calibration event register to verify that no errors were generated during the procedure.
 - If "0" is returned, the calibration was successful.
 - If "0" is not returned, the calibration attempt was unsuccessful. See Chapter 4, CALibrate Subsystem in the User's manual for more information.
16. Disconnect cable from input 2 and reconnect to EXT TRIG. Repeat steps 14 and 15 for external trigger.
17. When complete, disconnect BNC cable and perform the Logic Trigger Delay Calibration Procedure.

Example The following example shows how to perform a time null calibration. The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the Oscilloscope
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  !PROGRAM "TNULCAL"
20  !TIME NULL CALIBRATION
30  CLEAR SCREEN
40  PRINT "CONNECT PROBE COMP CAL/TRIG OUTPUT TO INPUT 1 AND 2"
50  PRINT "ACCESS AND ERROR LED's WILL BE ON DURING CALIBRATION"
60  PRINT "PRESS CONTINUE"
70  PAUSE
80  ASSIGN @Scope TO 70905      ! USE A VARIABLE FOR SCOPE ADDRESS
90  OUTPUT @Scope;"*CLS"
100 OUTPUT @Scope;"*RST"
110 OUTPUT @Scope;"SUMM:PRES"
120 OUTPUT @Scope;"CAL:SCAL:TNUL CH1TO2"
130 PRINT "CHANNEL 1 TO 2 TIME NULL CALIBRATION ROUTINE SELECTED"
140 OUTPUT @Scope;"CAL:SCAL:BCAL"
150 OUTPUT @Scope;"SUMM:QUES:CAL?"
160 ENTER @Scope;C
170 PRINT C, "CALIBRATION RESULTS"
180 PRINT "DISCONNECT CABLE FROM INPUT 2 AND RECONNECT TO EXT TRIG."
190 PRINT "PRESS CONTINUE"
200 PAUSE
210 OUTPUT @Scope;"CAL:SCAL:TNUL CH1TOEXT"
220 PRINT "CHANNEL 1 TO EXT TIME NULL CALIBRATION ROUTINE SELECTED"
230 OUTPUT @Scope;"CAL:SCAL:BCAL"
240 OUTPUT @Scope;"SUMM:QUES:CAL?"
250 ENTER @Scope;D
260 PRINT D, "CALIBRATION RESULTS"
270 PRINT "PROGRAM COMPLETED"
280 END

```


Logic Trigger Delay Calibration

18. Connect the Oscilloscope Probe Comp/Cal/Trig Output connector to the Input 1 connector using a BNC cable.

Note

Verify that the BNC cable is not longer than 1 meter.

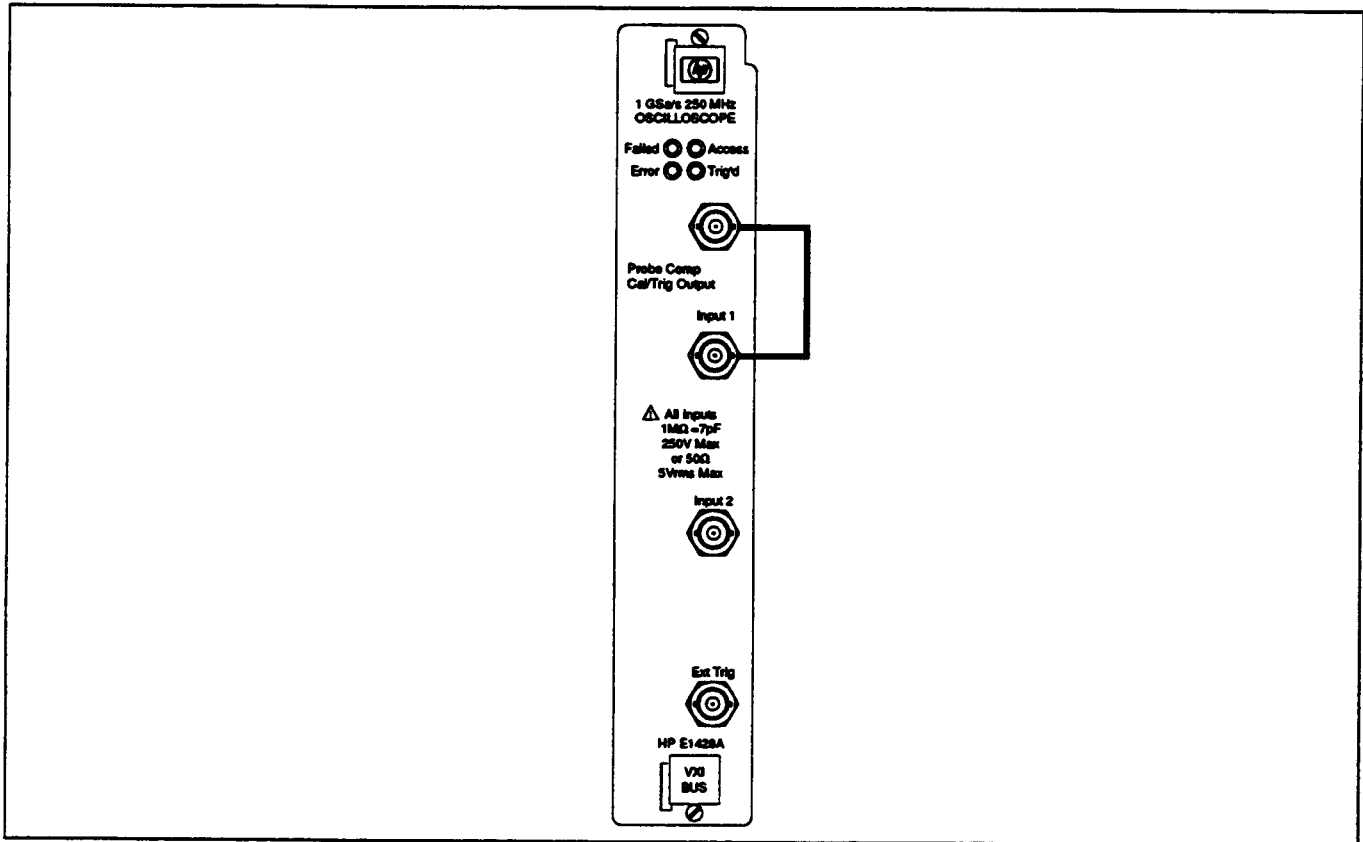


Figure 5-4. Example: Logic Trigger Delay Calibration Setup

19. Read the calibration register to verify that no errors are present.
 - If "0" is returned, proceed with step 20.
 - If "0" is not returned, the Logic Trigger Delay calibration must be terminated, and the cause of the error corrected. See Chapter 4, CALibrate Subsystem in the user's Manual for more information.
20. Perform clear status, reset, then preset the Oscilloscope.
21. Select and start the logic trigger calibration routine. Verify that the triggered LED flashes.

22. After calibration is complete (LED's to off), read the calibration register to verify that no errors were generated during the procedure.
 - If "0" is returned, the calibration was successful.
 - If "0" is not returned, the Logic Trigger Delay calibration must be terminated, and the cause of the error corrected. See Chapter 4, CALibrate Subsystem in the user's Manual for more information.
23. Disconnect BNC cable and set the Non-volatile RAM protection mode to ON (if desired).

Example The following example shows how to perform a logic trigger delay calibration. The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the Oscilloscope
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```

10  !PROGRAM "LTDELCAL"
20  !LOGIC TRIGGER DELAY CALIBRATION
30  CLEAR SCREEN
40  PRINT "CONNECT PROBE COMP CAL/TRIG OUTPUT TO INPUT 1"
50  PRINT "ACCESS AND ERROR LED WILL BE ON DURING CALIBRATION"
60  PRINT "PRESS CONTINUE"
70  PAUSE
80  ASSIGN @Scope TO 70905      ! USE A VARIABLE FOR SCOPE ADDRESS
90  OUTPUT @Scope;"*CLS"
100 OUTPUT @Scope;"*RST"
110 OUTPUT @Scope;"SUMM:PRES"
120 OUTPUT @Scope;"CAL:SCAL:LTC"
130 PRINT "LOGIC TRIGGER CALIBRATION ROUTINE SELECTED"
140 OUTPUT @Scope;"CAL:SCAL:BCAL"
150 OUTPUT @Scope;"SUMM:QUES:CAL?"
160 ENTER @Scope;E
170 PRINT E, "CALIBRATION RESULTS"
180 OUTPUT @Scope;"SYST:NVPR ON,'SYSTEM'"
190 PRINT "IF R208 (REF PARA 5-3) IS INSTALLED"
200 PRINT "PREVIOUS PROGRAM STEP WILL CAUSE ERROR"
210 PRINT "LED TO BE ON WHEN CALIBRATION IS COMPLETED"
220 PRINT "PROGRAM COMPLETED"
230 END

```

5-5. High Frequency Pulse Adjustment Procedure

The High Frequency Pulse Response adjustment is performed by applying a fast-rise pulse and adjusting overshoot to between 3% and 4%.

Note

This adjustment is performed **ONLY** when a vertical attenuator (AT1-2) has been replaced, or if the Bandwidth Test fails. A complete firmware calibration (paragraph 5-4) **MUST** be completed prior to performing this adjustment.

1. Remove the oscilloscope right side cover by removing eight Torx screws and loosening the four front panel BNC connector nuts. Locate the following adjustments (see Figure 5-5).

AT1 (channel 1) is A1 R747.

AT2 (channel 2) is A1 R748.

2. Connect the equipment as shown in Figure 5-5. Pulse Generator output is connected to the Input connector of the channel that is being adjusted using an SMA-BNC adapter (see table 1-1).

3. Set the Oscilloscope (on the channel being adjusted) as follows:

Reset Oscilloscope *RST
Perform an Autoscale AUT
Channel 1 Coupling to DC at 50Ω CHAN1:COUP DCF
Channel 1 Range to 320 mV CHAN1:RANG 400E-3
Channel 1 Offset to 300 mV CHAN1:OFFS 175E-3
Timebase to repetitive TIM:SAMP REP
Acquisition type to average ACQ:TYPE AVER
Acquisition count to 16 ACQ:COUN 16
Time Base Range to 50 nsec TIM:RANG 50E-9
Trigger source to channel 1 TRIG:SOUR CHAN1
Trigger level to 200 mV TRIG:LEV 200E-3
Trigger holdoff to 10 μsec TRIG:HOLD TIME 10E-6
Measurement source to channel 1 MEAS:SOUR CHAN1
Digitize channel 1 DIG CHAN1
Measure overshoot MEAS:OVER?

4. Verify measured result is $\geq 3\%$ and $\leq 4\%$.
 - If correct, proceed with step 5.
 - If $>4\%$, adjust the resistor (A1R747) CCW and repeat the procedure.
 - If $\leq 3\%$, adjust the resistor (A1R747) CW and repeat the procedure.
5. Repeat steps 2 through 4 for channel 2. Substitute adjustment in step 4 with A1R748.
6. Disconnect test equipment. Reinstall the oscilloscope right side cover.

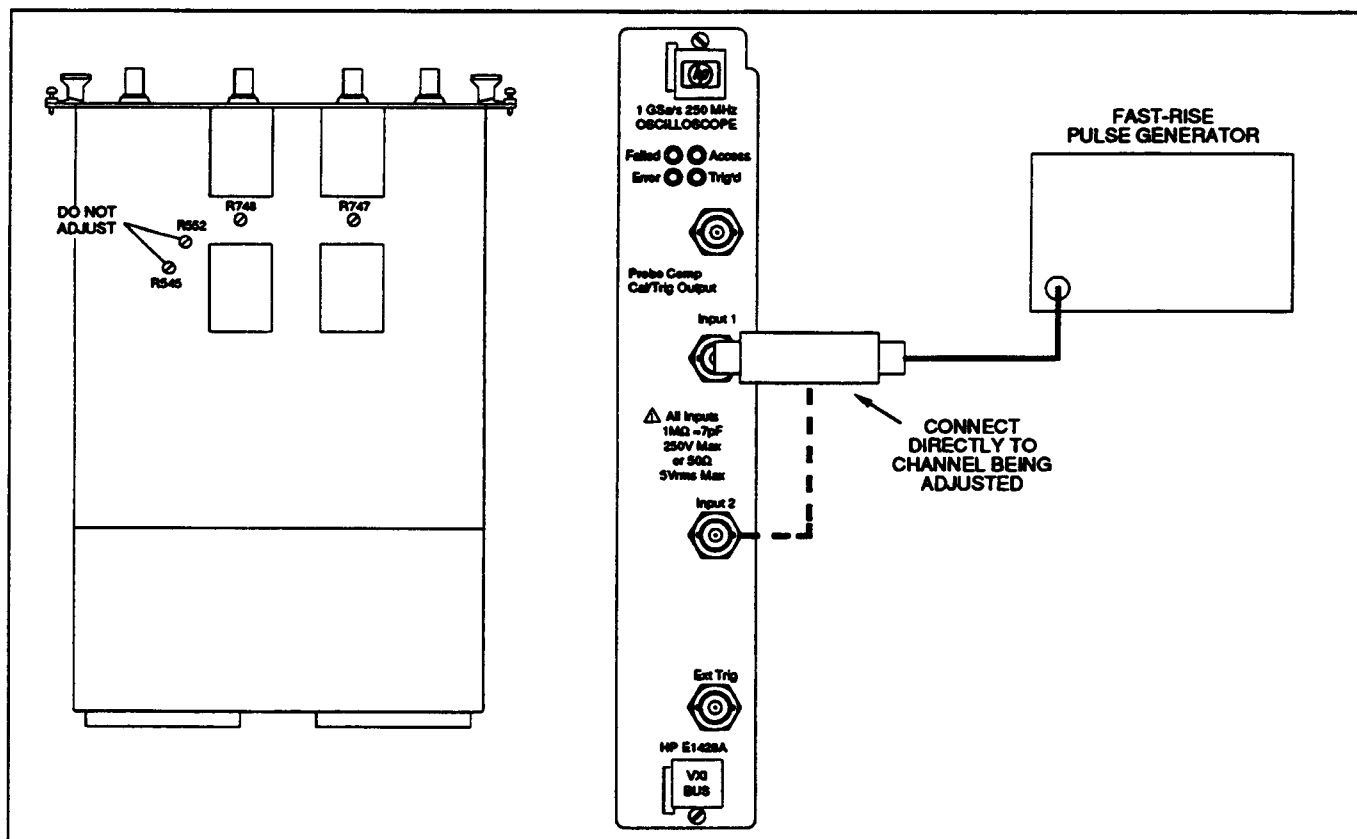


Figure 5-5. High Frequency Pulse Adjustment Setup

Example The following example shows how to perform a logic trigger delay calibration. The example is written using:

- an HP-IB select code of 7, primary address of 09, and secondary address of 05 for the Oscilloscope
- COMPatible programming language
- an HP Series 200/300 Computer with HP BASIC

Execute:

```
10  !PROGRAM "HFPAR"
20  !HIGH FREQUENCY PULSE ADJUSTMENT PROCEDURE
30  CLEAR SCREEN
40  PRINT "CONNECT SIGNAL GENERATOR TO CHANNEL1 INPUT"
50  PRINT "PRESS CONTINUE"
60  PAUSE
61  Channel=1
70  ASSIGN @Scope TO 70905
80  Retry1:  !
90  OUTPUT @Scope;"*CLS"
100 OUTPUT @Scope;"*RST"
110 OUTPUT @Scope;"AUT"
111 WAIT 2
120 OUTPUT @Scope;"CHAN"&VAL$(Channel)&":COUP DCF"
130 OUTPUT @Scope;"CHAN"&VAL$(Channel)&":RANG 400E-3"
140 OUTPUT @Scope;"CHAN"&VAL$(Channel)&":OFFS 175E-3"
142 OUTPUT @Scope;"TRIG:SOUR CHAN"&VAL$(Channel)
143 OUTPUT @Scope;"TRIG:LEVEL 200E-3"
150 OUTPUT @Scope;"TIM:RANG 50E-9"
160 OUTPUT @Scope;"TIM:SAMP REP"
170 OUTPUT @Scope;"ACQ:TYPE AVER:"
180 OUTPUT @Scope;"ACQ:COUN 16"
190 OUTPUT @Scope;"TRIG:HOLD TIME,10E-6"
200 OUTPUT @Scope;"DIG CHAN"&VAL$(Channel)
201 OUTPUT @Scope;"MEAS:SOUR CHAN"&VAL$(Channel)
210 OUTPUT @Scope;"MEAS:OVER?"
220 ENTER @Scope;Over
221 PRINT "OVERSHOOT = ";Over*100;"%"
230 IF Over> .04 OR Over<.03 THEN
250 PRINT "OVERSHOOT OUT OF SPECIFIED RANGE"
260 PRINT "SLOWLY ADJUST APPLICABLE RESISTOR TO CHANGE OVERSHOOT."
270 PRINT "CW INCREASES OVERSHOOT AND IMPROVES BANDWIDTH."
280 PRINT "CCW DECREASES OVERSHOOT AND DECREASES BANDWIDTH."
290 PRINT "REPEAT TEST"
300 PRINT "PRESS CONTINUE"
310 PAUSE
320 GOTO Retry1
330 END IF
340 PRINT "OVERSHOOT IS WITHIN RANGE"
341 IF Channel=2 THEN
342 PRINT "PROGRAM DONE"
343 STOP
344 END IF
350 PRINT "CONNECT SIGNAL TO CHANNEL 2.  PRESS CONTINUE."
351 PAUSE
353 Channel=2
354 GOTO Retry1
360 END
```


Replaceable Parts

6-1. Introduction

This chapter contains information for ordering parts. Table 6-1 lists exchange assemblies. Table 6-2 lists abbreviations used in the parts list and the manual. Table 6-3 lists all replaceable parts in reference designator order. Table 6-4 contains the names and addresses that correspond to the manufacturer's code numbers.

6-2. Ordering Information

To order a part listed in the replaceable parts table, quote the Hewlett-Packard part number (with the check digit), indicate the quantity required, and address the order to the nearest Hewlett-Packard office. The check digit will ensure accurate and timely processing of your order.

To order a part that is not listed in the replaceable parts table, include the instrument model number, instrument serial number, description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office.

6-3. Exchange Assemblies

Table 6-1 lists assemblies within the instrument that may be replaced on an exchange basis. Exchange, factory-repaired and tested assemblies are available only on a trade-in basis. Defective assemblies must be returned for credit. Assemblies required for spare parts stock must be ordered by the new assembly part number.

6-4. Abbreviations

Table 6-2 lists reference designators and abbreviations used in the parts list, schematics, and throughout the manual. In some cases, two forms of the abbreviation are used, one all in capital letters, and one with partial or no capitals. This occurs because the abbreviations in the parts list are always all capitals. However, in the schematics and other parts of the manual, other abbreviation forms are used with both lower case and upper-case letters.

6-5. Replaceable Parts List

Table 6-3 is the list of replaceable parts and is organized as follows:

- a. Electrical assemblies and their components in alpha-numerical order by reference designation.
- b. Chassis-mounted parts in alpha-numerical order by reference designation.
- c. Mechanical parts.

Information given for each part consists of the following:

- a. The Hewlett-Packard part number.
- b. Part number check digit (CD).
- c. The total quantity (Qty) for the entire instrument except for option assemblies.
- d. The description of the part.

- e. A typical manufacturer of the part in a five-digit code.
- f. The manufacturer's number for the part.

The total quantity for each part is given only once at the first appearance of the part number in the list for each major assembly.

Table 6-1. Part Numbers for Exchange Assemblies

Reference Designation	Description	Part Number*	
		Exchange Assy	New Assy
A1	Motherboard PCA	E1428-69501	E1428-66501
A2	Memory PCA	E1428-69502	E1428-66502
*When ordering extra assemblies for spare parts stock, use new assembly part number only. Exchange orders require return of the defective part.			

Table 6-2. Reference Designators and Abbreviations (1 of 2)

REFERENCE DESIGNATIONS

A assembly	E miscellaneous electrical part	P electrical connector (movable portion); plug	U integrated circuit; microcircuit
AT attenuator; isolator; termination	F fuse	Q transistor; SCR; triode thyristor	V electron tube
B fan; motor	FL filter	R resistor	VR voltage regulator; breakdown diode
BT battery	H hardware	RT thermistor	W cable; transmission path; wire
C capacitor	HY circulator	S switch	X socket
CP coupler	J electrical connector (stationary portion); jack	T transformer	Y crystal unit (piezo-electric or quartz)
CR diode; diode thyristor; varactor	K relay	TB terminal board	Z tuned cavity; tuned circuit
DC directional coupler	L coil; inductor	TC thermocouple	
DL delay line	M meter	TP test point	
DS annunciator; signaling device (audible or visual); lamp; LED	MP miscellaneous mechanical part		

ABBREVIATIONS

A ampere	COEF coefficient	EDP electronic data processing	INT internal
ac alternating current	COM common	ELECT electrolytic	kg kilogram
ACCESS accessory	COMP composition	ENCAP encapsulated	kHz kilohertz
ADJ adjustment	COMPL complete	EXT external	k Ω kilohm
A/D analog-to-digital	CONN connector	F farad	kV kilovolt
AF audio frequency	CP cadmium plate	FET field-effect transistor	lb pound
AFC automatic frequency control	CRT cathode-ray tube	F/F flip-flop	LC inductance-capacitance
AGC automatic gain control	CTL complementary transistor logic	FH flat head	LED light-emitting diode
AL aluminum	CW continuous wave	FIL H fillister head	LF low frequency
ALC automatic level control	cw clockwise	FM frequency modulation	LG long
AM amplitude modulation	D/A digital-to-analog	FP front panel	LH left hand
AMPL amplifier	dB decibel	FREQ frequency	LIM limit
APC automatic phase control	dBm decibel referred to 1 mW	FXD fixed	LIN linear taper (used in parts list)
ASSY assembly	dc direct current	g gram	lin linear
AUX auxiliary	deg degree (temperature interval or difference)	GE germanium	LK WASH lock washer
avg average	...° degree (plane angle)	GHz gigahertz	LO low; local oscillator
AWG American wire gauge	°C degree Celsius (centigrade)	GL glass	LOG logarithmic taper (used in parts list)
BAL balance	°F degree Fahrenheit	GRD ground(ed)	log logarithm(ic)
BCD binary coded decimal	°K degree Kelvin	H henry	LPF low pass filter
BD board	DEPC deposited carbon	h hour	LV low voltage
BE CU beryllium copper	DET detector	HET heterodyne	m metre (distance)
BFO beat frequency oscillator	diam diameter	HEX hexagonal	mA milliamperes
BH binder head	DIA diameter (used in parts list)	HD head	MAX maximum
BKDN breakdown	DIFF AMPL differential amplifier	HDW hardware	M Ω megohm
BP bandpass	div division	HF high frequency	MEG meg (10 ⁶) (used in parts list)
BPF bandpass filter	DPDT double-pole, double-throw	HG mercury	MET FLM metal film
BRS brass	DR drive	HI high	MET OX metallic oxide
BWO backward-wave oscillator	DSB doublesideband	HP Hewlett-Packard	MF medium frequency; microfarad (used in parts list)
CAL calibrate	DTL diode transistor logic	HPF high pass filter	MFR manufacturer
ccw counter-clockwise	DVM digital voltmeter	HR hour (used in parts list)	mg milligram
CER ceramic	ECL emitter coupled logic	HV high voltage	MHz megahertz
CHAN channel	EMF electromotive force	Hz Hertz	mH millihenry
cm centimetre		IC integrated circuit	mho mho
CMO cabinet mount only		ID inside diameter	MIN minimum
COAX coaxial		IF intermediate frequency	min minute (time)
		IMPG impregnated	... ' minute (plane angle)
		in inch	MINAT miniature
		INCD incandescent	mm millimetre
		INCL include(s)	
		INP input	
		INS insulation	

NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-2. Reference Designators and Abbreviations (2 of 2)

MOD modulator	OD outside diameter	PWV peak working voltage	TD time delay
MOM momentary	OH oval head	RC resistance-capacitance	TERM terminal
MOS metal-oxide semiconductor	OP AMPL operational amplifier	RECT rectifier	TFT ... thin-film transistor
ms millisecond	OPT option	REF reference	TGL toggle
MTG mounting	OSC oscillator	REG regulated	THD thread
MTR meter (indicating device)	OX oxide	REPL replaceable	THRU through
mV millivolt	oz ounce	RF radio frequency	TI titanium
mVac millivolt, ac	Ω ohm	RFI radio frequency interference	TOL tolerance
mVdc millivolt, dc	P peak (used in parts list)	RH round head; right hand	TRIM trimmer
mVpk millivolt, peak	PAM pulse-amplitude modulation	RLC resistance-inductance-capacitance	TSTR transistor
mVp-p millivolt, peak-to-peak	PC printed circuit	RMO rack mount only	TTL ... transistor-transistor logic
mVrms millivolt, rms	PCM ... pulse-code modulation; pulse-count modulation	rms root-mean-square	TV television
mW milliwatt	PDM pulse-duration modulation	RND round	TVI television interference
MUX multiplex	pF picofarad	ROM ... read-only memory	TWT... traveling wave tube
MY mylar	PH BRZ .. phosphor bronze	R&P rack and panel	U micro (10^{-6}) (used in parts list)
μ A microampere	PHL Philips	RWV reverse working voltage	UF microfarad (used in parts list)
μ F microfarad	PIN positive-intrinsic-negative	S scattering parameter	UHF .. ultrahigh frequency
μ H microhenry	PIV peak inverse voltage	s second (time)	UNREG unregulated
μ ho micromho	pk peak	"..." second (plane angle)	V volt
μ s microsecond	PL phase lock	S-B slow-blow (fuse) (used in parts list)	VA voltampere
μ V microvolt	PLO phase lock oscillator	SCR silicon controlled rectifier; screw	Vac volts, ac
μ Vac microvolt, ac	PM phase modulation	SE selenium	VAR variable
μ Vdc microvolt, dc	PNP positive-negative-positive	SECT sections	VCO voltage-controlled oscillator
μ Vpk microvolt, peak	P/O part of	SEMICON semiconductor	Vdc volts, dc
μ Vp-p microvolt, peak-to-peak	POLY polystyrene	SHF superhigh frequency	VDCW .. volts, dc, working (used in parts list)
μ Vrms microvolt, rms	PORC porcelain	SI silicon	V(F) volts, filtered
μ W microwatt	POS ... positive; position(s) (used in parts list)	SIL silver	VFO variable-frequency oscillator
nA nanoampere	POSN position	SL slide	VHF very-high frequency
NC no connection	POT potentiometer	SNR ... signal-to-noise ratio	Vpk volts, peak
N/C normally closed	p-p peak-to-peak	SPDT single-pole, double-throw	Vp-p volts, peak-to-peak
NE neon	PP peak-to-peak (used in parts list)	SPG spring	Vrms volts, rms
NEG negative	PPM pulse-position modulation	SR split ring	VSWR ... voltage standing wave ratio
nF nanofarad	PREAMPL ... preamplifier	SPST single-pole, single-throw	VTO voltage-tuned oscillator
NI PL nickel plate	PRF pulse-repetition frequency	SSE single sideband	VTVM vacuum-tube voltmeter
N/O normally open	PRR pulse repetition rate	SST stainless steel	V(X) volts, switched
NOM nominal	ps picosecond	STL steel	W watt
NORM normal	PT point	SQ square	W/ with
NPN ... negative-positive-negative	PTM pulse-time modulation	SWR... standing-wave ratio	WIV working inverse voltage
NPO negative-positive zero (zero temperature coefficient)	PWM pulse-width modulation	SYNC synchronize	WW wirewound
NRFR... not recommended for field replacement		T ... timed (slow-blow fuse)	W/O without
NSR not separately replaceable		TA tantalum	YIG ... yttrium-iron-garnet
ns nanosecond		TC temperature compensating	Z ₀ characteristic impedance
nW nanowatt			
OBD order by description			

NOTE

All abbreviations in the parts list will be in upper-case.

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^9
M	mega	10^6
k	kilo	10^3
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

Table 6-3. Replaceable Parts

Reference Designator	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	E1428-66501		1	Motherboard Printed Circuit Assembly	28480	E1428-66501
A1	E1428-69501		1	Motherboard PCA (Exchange) (repair limited to replacement of these parts)	28480	E1428-69501
A1AT1	54512-63402		2	Vertical Attenuator	28480	54512-63402
A1AT2	54512-63402			Vertical Attenuator	28480	54512-63402
A1F1	2110-0699		6	Fuse-Sub Miniature-5A	28480	2110-0699
A1F2	2110-0699			Fuse-Sub Miniature-5A	28480	2110-0699
A1F3	2110-0699			Fuse-Sub Miniature-5A	28480	2110-0699
A1F4	2110-0699			Fuse-Sub Miniature-5A	28480	2110-0699
A1F5	2110-0699			Fuse-Sub Miniature-5A	28480	2110-0699
A1F6	2110-0699			Fuse-Sub Miniature-5A	28480	2110-0699
A1J1	1250-2012		2	Connector, BNC female, 50 ohms	28480	1250-2012
A1J2	1250-2012			Connector, BNC female, 50 ohms	28480	1250-2012
A2	E1428-66502		1	Memory Printed Circuit Assembly	28480	E1428-66502
A2	E1428-69502		1	Memory Printed Circuit Assembly (Exchange)	28480	E1428-69502
MECHANICAL PARTS						
MP1	E1428-00201		1	Front Panel	28480	E1428-00201
MP2	E1428-00601		1	Shield, Top (Right)	28480	E1428-00601
MP3	E1428-00602		1	Shield, Bottom (Left)	28480	E1428-00602
MP4	8160-0686		AR	RFI Strip Fingers	28480	8160-0686

See introduction to this section for ordering information

* Indicates factory selected value

† Backdating information in section VII

Table 6-4. Code List of Manufacturers

Mfr Code	Manufacturer Name	Address	Zip Code
00000	ANY SATISFACTORY SUPPLIER		
28480	HEWLETT-PACKARD COMPANY CORPORATE HEADQUARTERS	PALO ALTO CA	94304

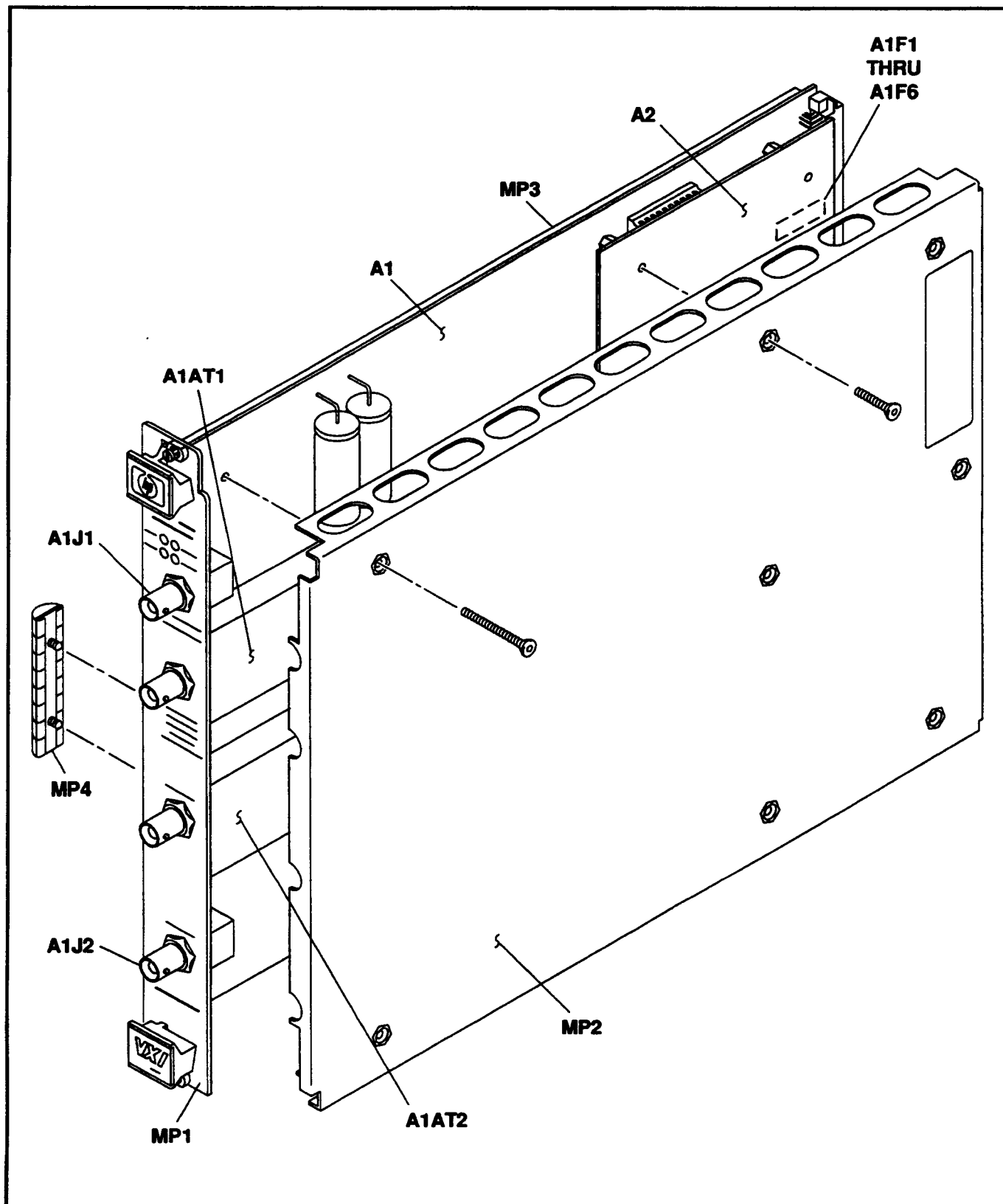


Figure 6-1. Oscilloscope Replaceable Parts

Manual Changes

7-1. Introduction

This section normally contains information for adapting this manual to instruments for which the content does not apply directly. Since this manual does apply directly to instruments having serial numbers listed on the title page, no change information is given here. Refer to **INSTRUMENTS COVERED BY THIS MANUAL** in Chapter 1 for additional important information about serial number coverage.

8-1. Introduction

This chapter contains information for servicing the HP E1428A Oscilloscope. Included are procedures for troubleshooting, repair, disassembly, and re-assembly.

8-2. Safety Considerations

This paragraph contains information, cautions, and warnings which must be followed for your protection and to avoid damage to the equipment when repairing the Oscilloscope.

Warning

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.) In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Maintenance described in the manual is performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury. Where maintenance can be performed without power applied, the power should be removed.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.). Do not use repaired fuses or short circuited fuseholders.

Caution

Do not disconnect or remove any modules in the mainframe unless the mainframe is unplugged. Some modules contain devices that can be damaged if the board is removed when the power is on. Several components, including MOS devices, can be damaged by electrostatic discharge. Use conductive foam and grounding straps when servicing is required on sensitive components. Use care when unplugging ICs from high-grip sockets.

8-3. Equipment Required

Equipment required for troubleshooting and repair of the mainframe is listed in Table 1-1, Recommended Test Equipment. Any equipment that satisfies the critical specifications given in the table may be substituted.

Pozidriv Screwdrivers

Many screws in the mainframe appear to be Phillips type, but are not. To avoid damage to the screw head slots, Pozidriv screwdrivers should be used. HP P/N 8710-0899 is the No. 1 Pozidriv and HP P/N 8710-0900 is the No. 2 Pozidriv.

Torx Screwdrivers

Some screws in the mainframe appear to be Hex type, but are not. To avoid damage to the screw heads, Torx screwdrivers must be used. HP 8710-1284 is size T-10.

8-4. Troubleshooting

8-5. General

Oscilloscope problems usually fall into four general categories: turn-on errors, operator errors, instrument performance out of specification, and catastrophic failures. The troubleshooting strategy is different for each category.

- **Turn-on Errors:** An error number (other than "0") returned when an instrument self-test fails indicating that the built-in diagnostic routine has detected some problem. Recycle power and repeat the self-test. If the error repeats, troubleshooting using the procedures in paragraph 8-8.
- **Operator Errors:** Apparent failures often result from operator errors. Refer to the "HP E1428A Users Manual", Appendix B for additional information on these errors.
- **Instrument Performance Out of Specification:** If a parameter is out of limits, use the adjustment procedures in Chapter 5 to correct the problem.
- **Catastrophic Failure :** When a catastrophic failure occurs, troubleshooting using the procedures in paragraph 8-8.

8-6. Service Aids

The following information is provided to assist the technician when performing maintenance on the Oscilloscope.

Assembly, Parts and Cable Locations

For specific assembly/component descriptions and ordering information, refer to table 6-3, "Replaceable parts", in Chapter 6. Chassis and frame parts, as well as mechanical parts (MP's) and cables (W or CBL), are identified in the illustrated parts breakdown (IPB) in Chapter 6.

Test Points and Adjustment Locations

There are no test points for the Oscilloscope. Manual adjustment locations are provided in Chapter 5.

Service Aids on Printed Circuit Boards

Service aids on printed circuit boards include pin numbers, some reference designations, and assembly part numbers.

Other Service Documents

Service Notes, *Manual Updates*, and other service literature are available through Hewlett-Packard. For further information, contact your nearest Hewlett-Packard office.

8-7. Visual Inspection

Visually inspect the Oscilloscope for any signs of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing. Determine and remedy the cause of any such condition.

Switch Settings

Verify the logical address setting is set to the correct setting (factory set at 40).

Verify the bus request/grant level setting is set to the correct setting (factory set at level 00).

Note

Refer to the HP E1428A User's Manual for more information.

Connections

Verify that all connector contacts are not damaged, and that all cable connectors are making positive contact.

- Panel BNC Connectors.
- Backplane connector contacts.
- Ribbon cable connector contacts.

8-8. Troubleshooting Test

Perform the following steps to isolate a malfunction within the Oscilloscope to a user replaceable component.

Note

Chapter 6 contains a list of all user replaceable parts. If a part is not listed, return the defective PCA to Hewlett-Packard for exchange.

1. Perform clear status (*CLS), reset (*RST), then preset (SUMM:PRES) the Oscilloscope.
2. Execute the Oscilloscope self diagnostic using the **TEST:TALL** command.
3. After the test is complete, read the results in the summary questionable test event register (SUMM:QUES:TEST?).

If "0" is returned, then no error has occurred. Proceed with step 4.

If "0" is not returned, query the individual TEST event registers to determine the malfunction. Use the information provided below to help isolate the problem. See Chapter 4 or 6 in the E1428A User's Manual for querying test results in the individual registers.

Test Failure	Probable Cause/Action
Display RAM	Not Applicable
System RAM	A2 PCA malfunction. Return for exchange.
Non-volatile RAM	A2 PCA malfunction. Return for exchange.
Acquisition RAM	A1 PCA malfunction. Return for exchange
Logic Trigger	A1 PCA malfunction. Return for exchange.
Analog Trigger	A1 PCA malfunction. Return for exchange.
Time Base	A1 PCA malfunction. Return for exchange
D/A Converter	A1 PCA malfunction. Return for exchange
A/D Converter	A1 PCA malfunction. Return for exchange

4. Disconnect power and remove oscilloscope from the mainframe. Remove the oscilloscope top cover, and separate A2 Memory PCA A1 Motherboard PCA (see information in this chapter). Use the following information to isolate the problem to a user replaceable part.

Step	Description	Probable Cause/Action
1.	Power Supplies	1. Check A1F1 through A1F6. 2. Check A1P1/P2.
2.	Signal Connection	1. Check all connectors. 2. Check all contacts. 3. Check all cables.
3.	Visual Inspection/Improper Operation	1. Inspect (see next page). 2. Verify connection. 3. Verify proper operation.

5. If malfunction cannot be isolated to a user replaceable component, return the Oscilloscope to Hewlett-Packard for repair.

8-9. Repair and Replacement

8-10. Disassembly and Reassembly

Procedures are provided for disassembly and re-assembly of the following items:

- A1 Motherboard Printed Circuit Assembly
- A2 Memory Printed Circuit Assembly
- AT1 and AT2 Vertical Attenuators

A1 Motherboard Printed Circuit Assembly

1. Remove the A2 Memory PCA (see instructions in this chapter).

Caution

Static electricity is a major cause of component failure. To prevent damage to the electrical components in the Digitizing Oscilloscope, observe anti-static techniques whenever working on the Oscilloscope.

2. Remove the six 1/4 in. threaded stand-off from the rear center of the board, and the bottom shield.
3. Remove the four connector nuts.
4. Remove two Torx screws and washers.
5. Remove the front panel.
6. Reverse order to reinstall A1 Motherboard PCA.

A2 Memory Printed Circuit Assembly

1. Remove two long Torx, and six short Torx flathead screws.
2. Loosen the four connector nuts.
3. Remove the top shield.

Caution

Static electricity is a major cause of component failure. To prevent damage to the electrical components in the Digitizing Oscilloscope, observe anti-static techniques whenever working on the Oscilloscope.

4. Separate the A2 Memory PCA from the A1 Motherboard PCA (two connectors).
5. Reverse order to reinstall A2 Memory PCA.

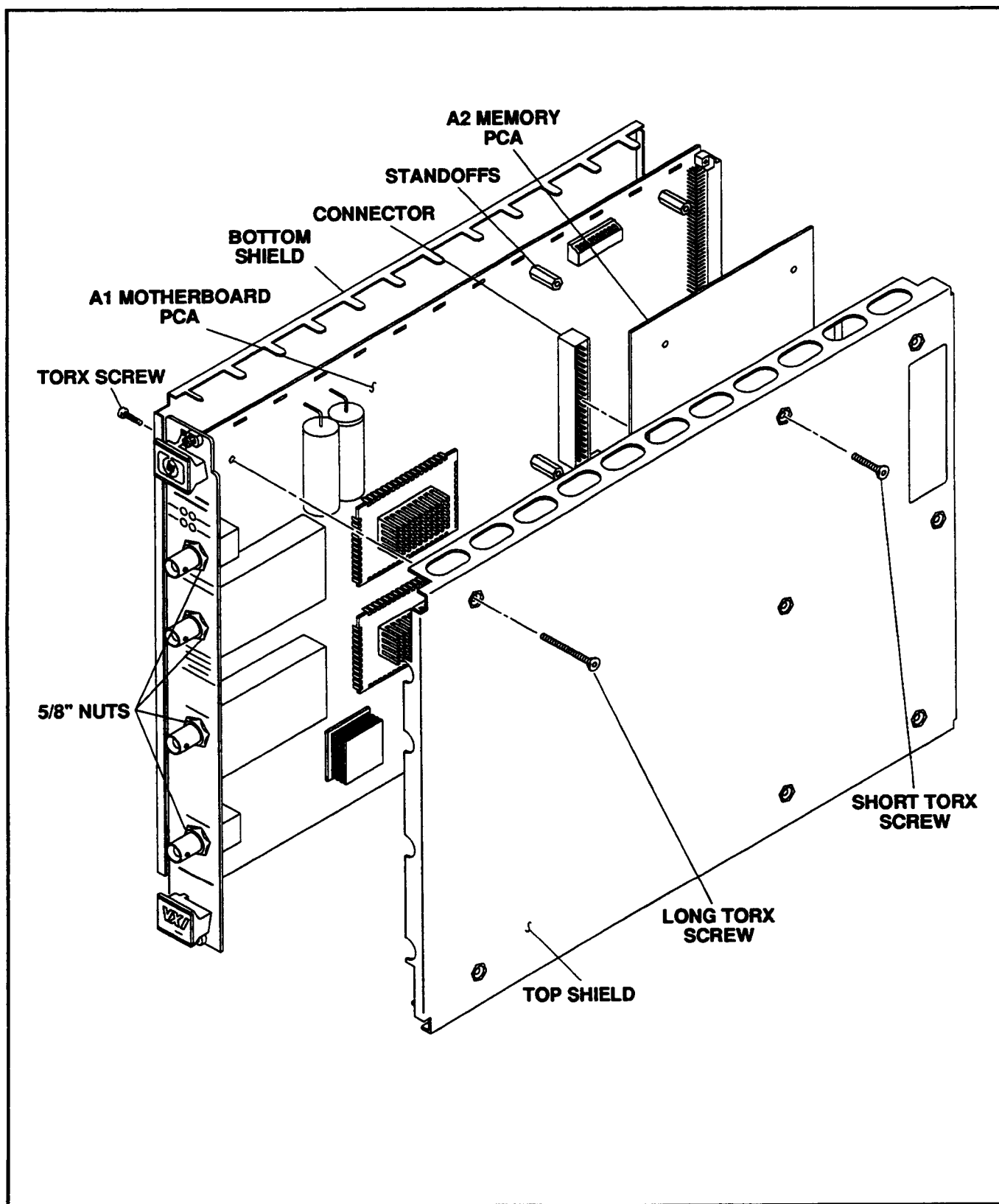


Figure 8-1. A1/A2 PCA Removal

AT1 and AT2 Vertical Attenuators

1. Remove the A1 Motherboard PCA (see instructions in this chapter).
2. Remove the two Torx T10 pan head screws from the circuit side of the board.
3. Lift straight-up to unplug and remove the Vertical Attenuator.
4. Reverse order to reinstall AT1 or AT2 Vertical attenuators.
5. Perform High Frequency Pulse Adjustment (see instructions in chapter 5).

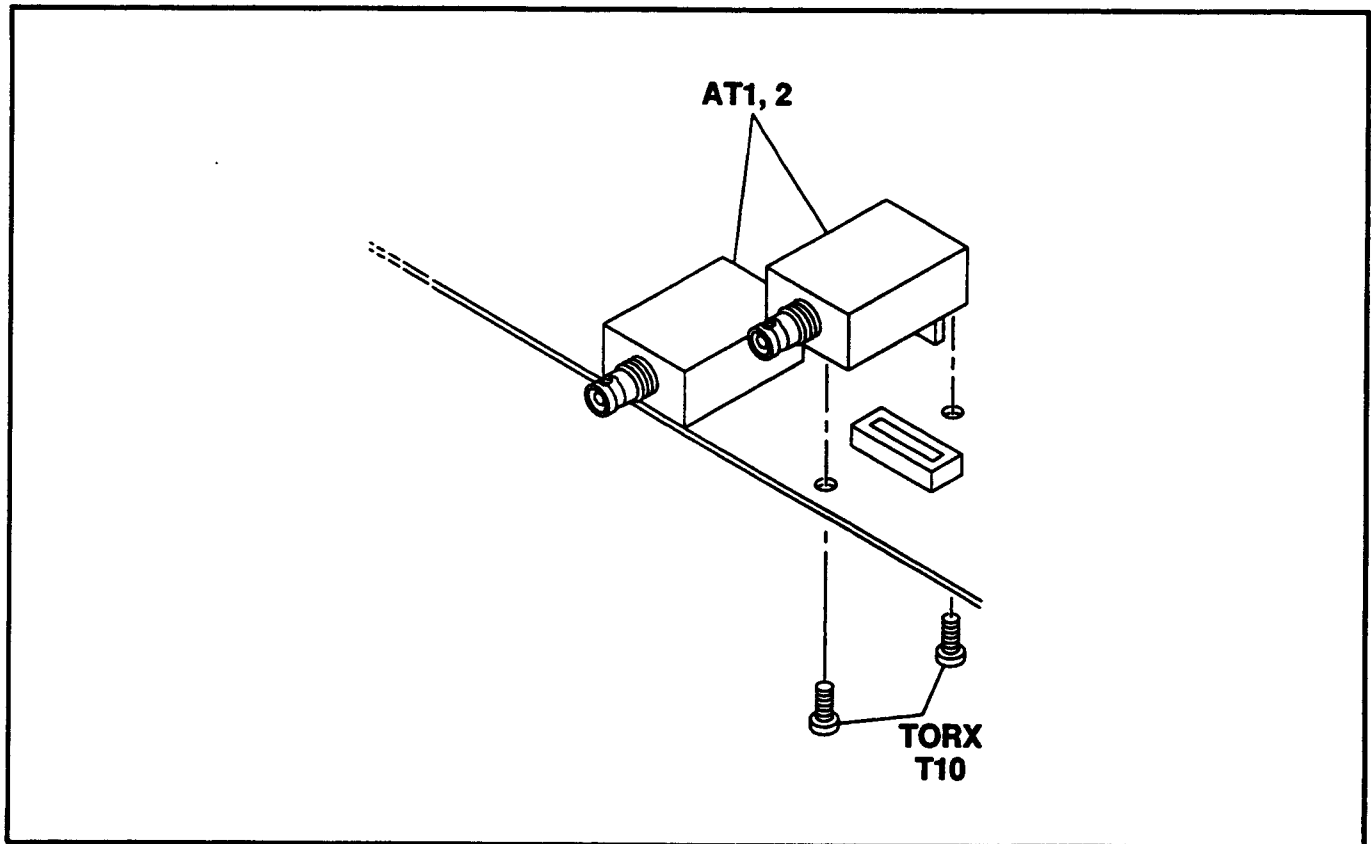


Figure 8-2. AT1/2 Vertical Attenuator Removal

8-11. Repair

The following information is provided to assist the technician in repairing the Oscilloscope:

Etched Circuits (Printed Circuit Boards)

The etched circuit boards in the Oscilloscope have plated through holes which make a solder path through to both sides of the insulating material. Soldering can be done from either side of the board with equally good results. When soldering to any circuit board, keep in mind the following recommendations:

1. Avoid unnecessary component unsoldering and soldering. Excessive replacement can result in damage to the circuit board and/or adjacent components.
2. Do not use a high power soldering iron on etched circuit boards. A 38-watt soldering iron is recommended. Excessive heat may lift a conductor or damage the board.

Caution

Do not use a sharp metal object such as an awl or twist drill in the following step. Sharp objects may damage the plated through conductor.

3. Use a suction device or wooden toothpick to remove solder from component mounting holes. When using a suction device make sure that equipment is properly grounded to prevent electrostatic discharge from damaging MOS devices.

Electrostatic Discharge (ESD) Precautions

Electrostatic discharge (ESD) can cause damage to certain assemblies in the Oscilloscope. The damage can range from slight degradation of a parameter to catastrophic failures.

MOS, CMOS, and other static sensitive devices are used in this instrument. They are prone to damage from both static electricity and transient signals. They must be handled carefully. When working on the Oscilloscope assemblies, keep in mind the following recommendations to avoid damaging these sensitive components.

1. Use a static-free work station with a pad of conductive rubber or similar material.
2. After removing assemblies from the Oscilloscope, be sure that they are placed on a conductive surface to guard against ESD damage. Do not stack boards.
3. When removing a MOS or CMOS device from a high grip socket, be careful not to damage it. Avoid removing devices from these sockets with pliers. Instead, use a small screwdriver to pry the device up from one end, slowly pulling it up one pair of pins at a time.
4. Once a MOS or CMOS device has been removed from an assembly, immediately stick it into a pad of conductive foam or other suitable holding medium.

5. When replacing a MOS or CMOS device, ground the foam on which it resides to the instrument before removing it. If a device requires soldering, make sure that the assembly is lying on a pad of conductive material, and that the pad, soldering iron tip, and personnel, are grounded to the assembly. Apply as little heat as possible.
6. Before turning the instrument off, remove any large ac sources that may be driving MOS switches.

Assembly Exchange Program

Table 6-1 lists assemblies that are available on an exchange basis. Refer to the table, and the "Exchange Assemblies" paragraph in Chapter 6 for further information.

Limited Repair Assemblies

Repair of non-exchange assemblies is limited to replacement of selected parts. Replaceable parts (fuses, connectors, hardware) for all Oscilloscope assemblies are listed in table 6-2.

Post Repair Adjustments

Adjustment procedures are provided in Chapter 5.

Post Repair Safety Checks

Visually inspect the Oscilloscope for any signs of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing. Determine and remedy the cause of any such condition.

References

Referenced Publications

This appendix lists all operating, installation, and service manuals referenced in this manual.

Publication Title	Publication Part Number	Ordering Address
HP E1400B User's Manual	E1400-90005	See Sales and Support Offices listed in the back of this manual
HP E1405A User's Manual	E1405-90001	See Sales and Support Offices listed in the back of this manual
HP E1428A User's Manual	E1428-97001	See Sales and Support Offices listed in the back of this manual
HP E1428A Service Manual	E1428-97002	See Sales and Support Offices listed in the back of this manual
