Agilent 75000 SERIES C

Agilent E1445A
Arbitrary Function Generator

Service Manual

Serial Numbers

This manual applies directly to instruments with serial numbers prefixed with 3144A.

Manual Part Number: E1445-90011

Printed: November 2005 Edition 2
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Contents

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Agilent Technologies certifies that this product met its published specifications at the time of shipment from the factory. Agilent Technologies 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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Agilent E1445A Arbitrary Function Generator Service Manual
Edition 2

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 E1445-90010). September 1992

Edition 2 (Part Number E1445-90011). September 1996

Safety Symbols

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

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

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

Alternating current (AC).

Direct current (DC).

Indicates hazardous voltages.

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

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

WARNINGS

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. Agilent Technologies 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 fuse holders.

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 an Agilent Technologies 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 an Agilent Technologies Sales and Service Office for service and repair to ensure that safety features are maintained.

Agilent Technologies	**DECLARATION OF CONFORMITY** According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014	CE

Manufacturer's Name: Agilent Technologies, Incorporated
Manufacturer's Address: 815 – 14th St. SW
Loveland, Colorado 80537
USA

Declares, that the product

Product Name: Arbitrary Function Generator
Model Number: E1445A
Product Options: *This declaration covers all options of the above product(s).*

Conforms with the following European Directives:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly.

Conforms with the following product standards:

EMC	Standard	Limit
	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	
	CISPR 11:1990 / EN 55011:1991	*Group 1 Class A*
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995	*4kV CD, 8kV AD*
	IEC 61000-4-3:1995 / EN 61000-4-3:1995	*3 V/m, 80-1000 MHz*
	IEC 61000-4-4:1995 / EN 61000-4-4:1995	*0.5kV signal lines, 1kV power lines*
	IEC 61000-4-5:1995 / EN 61000-4-5:1995	*0.5 kV line-line, 1 kV line-ground*
	IEC 61000-4-6:1996 / EN 61000-4-6:1996	*3V, 0.15-80 MHz I cycle, 100%*
	IEC 61000-4-11:1994 / EN 61000-4-11:1994	*Dips: 30% 10ms; 60% 100ms* *Interrupt > 95%@5000ms*
	Canada: ICES-001:1998	
	Australia/New Zealand: AS/NZS 2064.1	

The product was tested in a typical configuration with Agilent Technologies test systems.

Safety
IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995
Canada: CSA C22.2 No. 1010.1:1992
UL 3111-1: 1994

1 June 2001
Date

Ray Corson
Product Regulations Program Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor.
Authorized EU-representative: Agilent Technologies Deutschland GmbH, Herrenberger Straße 130, D 71034 Böblingen, Germany

Notes

Chapter 1
General Information

Introduction

This manual contains information required to test, troubleshoot, and repair the Agilent E1445A C-Size VXI Arbitrary Function Generator (AFG). See the *Agilent E1445A User's Manual* for additional information. Figure 1-1 shows the Agilent E1445A. This chapter includes the following sections:

- Introduction
- Safety Considerations
- Inspection/Shipping
- Environment
- AFG Description
- Recommended Test Equipment

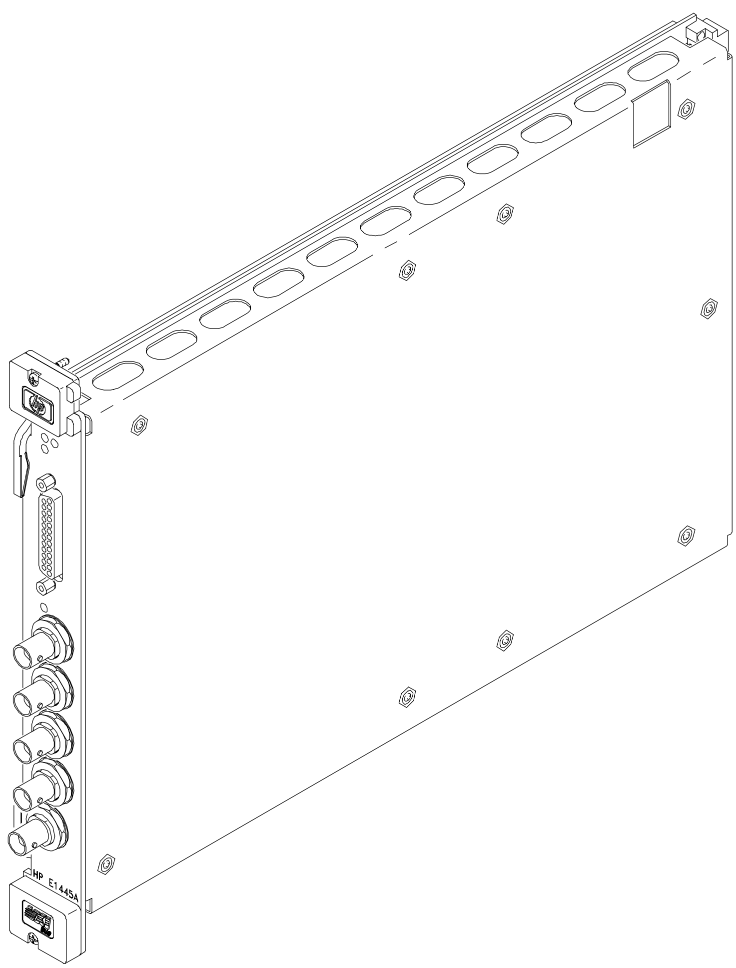


Figure 1-1. E1445A Arbitrary Function Generator

Safety Considerations

This product is a Safety Class I instrument that is provided with a protective earth terminal when installed in the mainframe. The mainframe, AFG, and all related documentation should be reviewed for familiarization with safety markings and instructions before operation or service.

Refer to the WARNINGS page (page 4) in this manual for a summary of safety information. Safety information for preventive maintenance, testing, and service follows and is also found throughout this manual.

Warnings and Cautions

This section contains WARNINGS which must be followed for your protection and CAUTIONS which must be followed to avoid damage to the equipment when performing instrument maintenance or repair.

WARNING

SERVICE-TRAINED PERSONNEL ONLY. The information in this manual is for service-trained personnel who are familiar with electronic circuitry and are aware of the hazards involved. To avoid personal injury or damage to the instrument, do not perform procedures in this manual or do any servicing unless you are qualified to do so.

CHECK MAINFRAME POWER SETTINGS. Before applying power, verify that the mainframe setting matches the line voltage and that the correct fuse is installed. An uninterruptible safety earth ground must be provided from the main power source to the supplied power cord set.

GROUNDING REQUIREMENTS. Interruption of the protective (grounding) conductor (inside or outside the mainframe) 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.)

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

REMOVE POWER IF POSSIBLE. Some procedures in this manual may be performed with power supplied to the mainframe while protective covers are removed. Energy available at many points may, if contacted, result in personal injury. (If maintenance can be performed without power applied, the power should be removed.)

WARNING

USING AUTOTRANSFORMERS. If the mainframe 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 main's supply).

CAPACITOR VOLTAGES. Capacitors inside the mainframe may remain charged even when the mainframe has been disconnected from its source of supply.

USE PROPER FUSES. For continued protection against fire hazard, replace the line fuses only with fuses of the same current rating and type (such as 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 AFG, observe anti-static techniques whenever working on the AFG.

Inspection/ Shipping

This section describes initial (incoming) inspection and shipping guidelines for the AFG.

Initial Inspection

Use the steps in Figure 1-2 as guidelines to perform initial inspection of the AFG.

WARNING

To avoid possible hazardous electrical shock, do not perform electrical tests if there are signs of shipping damage to the shipping container or to the instrument.

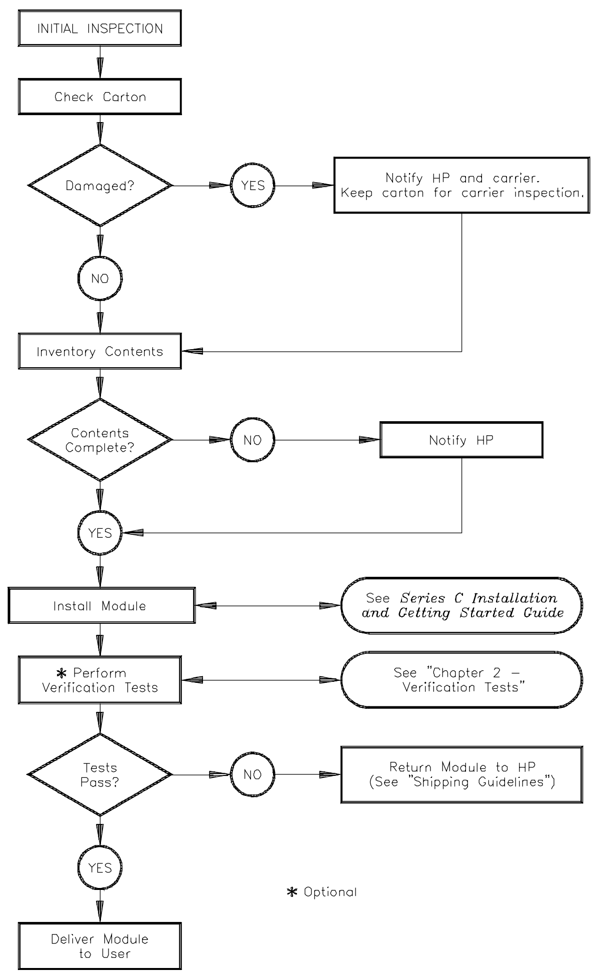
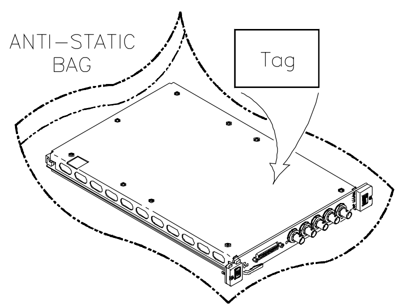


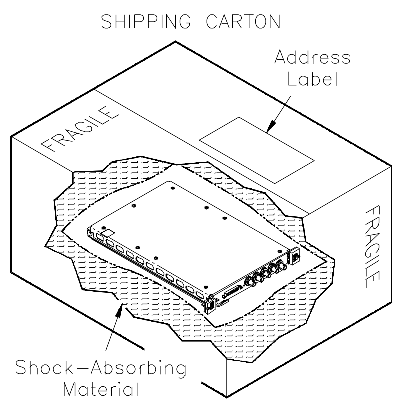
Figure 1-2. Initial (Incoming) Inspection Guidelines

Shipping Guidelines

Follow the steps in Figure 1-3 to return the AFG to an Agilent Technologies Sales and Support Office or Service Center.



1. Prepare the module
   - Remove user wiring from terminal block
   - Attach tag to module that identifies:
     - Owner
     - Model Number/Serial Number
     - Service Required
   - Place tagged device in approved anti-static bag



2. Package the module
   - Place packaged module in shipping carton*
   - Place 75 to 100 mm (3 to 4 inches) of shock-absorbing material around the module
   - Seal the shipping container securely
   - Mark the shipping container FRAGILE

3. Ship the module to Agilent Technologies
   - Place address label on shipping carton
   - Send carton to Agilent Technologies

* We recommend that you use the same shipping materials as those used in factory packaging (available from Agilent Technologies). For other (commercially-available) shipping materials, use a double-wall carton with minimum 2.4 MPa (350 psi) test.

Figure 1-3. Packaging/Shipping Guidelines

Environment

The recommended operating environment for the Agilent E1445A AFG is:

Environment	Temperature	Humidity
Operating	0^oC to $+55^oC$	<65% relative (0^oC to $+40^oC$)
Storage and Shipment	-40^oC to $+75^oC$	<65% relative (0^oC to $+40^oC$)

AFG Description

The Agilent E1445A Arbitrary Function Generator is a VXIbus C-size, message-based instrument. The AFG can operate in a C-size VXIbus mainframe using an Agilent E1405/E1406 Command Module and Standard Commands for Programmable Instruments (SCPI).

The AFG has 13 bits of resolution (including sign). It uses a sequencer architecture, with 256K points of Segment storage and 32K points of Sequence storage. The AFG has two internal timebases, 40 MHz and (approximately) 42.9 MHz.

AFG Specifications

AFG specifications are listed in Appendix A of the *Agilent E1445A User's Manual*. These specifications are the performance standards or limits against which the instrument may be tested.

AFG Options

Arbitrary Waveform Generation Software for HP 9000 Series 300 computers can be ordered as Option 005.

AFG Serial Numbers

Figure 1-4 shows Agilent Technologies' serial number structure. AFG's covered by this manual are identified by a serial number prefix listed on the title page.

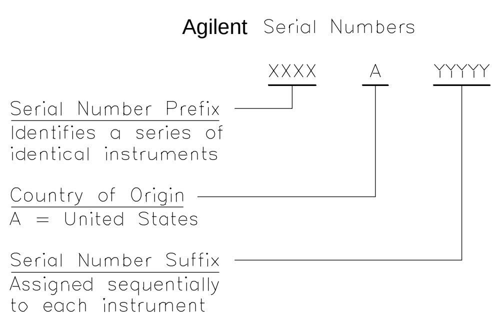


Figure 1-4. Agilent Serial Numbers

Recommended Test Equipment

Table 1-1 lists the test equipment recommended for testing, adjusting, and servicing the AFG. Essential requirements for each piece of test equipment are described in the Requirements column.

Table 1-1. Recommended Test Equipment

Instrument	Requirements	Recommended Model	Use*
Controller, GP-IB	GP-IB compatibility as defined by IEEE Standard 488-1988 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 9000 Series 300 or IBM Compatible PC with HP BASIC	F,O,P, A,T
Mainframe	Compatible with AFG	Agilent E1401B/T or E1421B	F,O,P, A,T
Command Module	10 MHz Clk Out TTL compatible Trig Out	Agilent E1405B or Agilent E1406A	F,O,P, A,T
Digital Multimeter	DCV, ACV, 4-wire ohms w/offset comp	Agilent 3458A	O,P,A
Power Meter	Frequency Range: 400 kHz - 10.8 MHz	Agilent 8902A	O,P,A
Power Sensor	Frequency Range: 400 kHz - 10.8 MHz	Agilent 11722A	O,P,A
Counter	Frequency Range: 100 Hz - 45 MHz	Agilent 5334A/B	O,P
Spectrum Analyzer	Frequency Range: 100 kHz - 150 MHz	Agilent 8566B	O,P,A
Oscilloscope	General Purpose Bandwidth: 20 MHz	Agilent 54111D	F
50 Ω feed-thru termination	50 ±0.10 Ω	Agilent 11048C	O,P,A

* F = Functional Verification, O = Operation Verification Tests, P = Performance Verification Tests, A = Adjustments, T = Troubleshooting

Chapter 2
Verification Tests

Introduction

The three levels of test procedures described in this chapter are used to verify that the Agilent E1445A:

- is fully functional (Functional Verification)
- meets selected testable specifications (Operation Verification)
- meets all testable specifications (Performance Verification)

WARNING

Do not perform any of the following verification tests unless you are a qualified, service-trained technician and have read the WARNINGS and CAUTIONS in Chapter 1.

Test Conditions/ Procedures

See Table 1-1 for test equipment requirements. You should complete the Performance Verification tests at least once a year. For heavy use or severe operating environments, perform the tests more often.

Before performing these tests, allow the AFG to warm up for at least one hour. The temperature should be within $\pm 5^{o}$C of T_{cal} (the temperature of the most recent calibration), and between 18^{o}C and 28^{o}C.

The verification tests assume that the person performing the tests understands how to operate the mainframe, the AFG, and specified test equipment. The test procedures do not specify equipment settings for test equipment, except in general terms. It is assumed that a qualified, service-trained technician will select and connect the cables, adapters, and probes required for the test.

Performance Test Record

The results of each Performance Verification test may be recorded in Table 2-11, *Agilent E1445A Performance Test Record*. This form can be copied.

Verification Test Examples

Each verification test procedure includes an example program that performs the test. All example programs assume the following configuration:

- Controller is an HP 9000 Series 200/300 computer
- Programming language is HP BASIC
- AFG address is 70910

Command Coupling

Many of the AFG SCPI commands are value-coupled. In order to prevent "Settings Conflict" errors, coupled commands must be sent contiguously by placing them in the same program line, or by suppressing the end-of-line terminator. (For more information on command coupling and syntax, see Chapter 1 of the *Agilent E1445A User's Manual*). In HP BASIC, the end-of-line terminator can be suppressed by linking the commands with a semi-colon (;) and a colon (:), as illustrated below:

```
ROSC:SOUR INT1;
:TRIG:SOUR INT1
```

In the Example programs, these commands would appear as follows:

```
OUTPUT 70910;"ROSC:SOUR:INT1;";
OUTPUT 70910;":TRIG:SOUR:INT1"
```

Functional Verification

The purpose of these tests is to verify that the AFG is functioning properly and that all front panel inputs and outputs are working. No attempt is made to verify that the AFG is meeting specifications. Functional Verification for the AFG includes the following tests:

- Self-Test
- Ref In/Marker Out Test
- Start Arm In Test
- Gate In Test
- Output Relay Test

NOTE *For a quick functional check of the AFG, perform only the Self-Test.*

An example program that performs all of the Functional Verification tests is included at the end of this section. An Agilent E1405/E1406 Command Module is required for this program.

NOTE *Some of the tests use the "TRIG OUT" port of the Command Module. This port uses negative logic, i.e., the high voltage is a logical 0 and the low voltage is a logical 1.*

Functional Verification: Self-Test

Description

The AFG self-test performs the following internal checks:

- internal interrupt lines
- waveform select RAM
- segment sequence RAM
- waveform segment RAM
- DDS/NCO operation
- sine wave generation
- arbitrary waveform generation
- marker generation
- waveform cycle and arm counters
- sweep timer
- frequency-shift keying
- stop trigger
- DC analog parameters (amplitude, offset, attenuators, filters, calibration DACs)

Test Procedure

1. Remove any connections to the AFG front panel.

2. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

3. Execute the AFG self-test:

*TST?	*Self-test command*

4. Read the result. A "0" indicates that the test passed. A "1" indicates a failure. Read the error queue using the SYST:ERR? command until the error message is "No error".

Functional Verification: Ref In/Marker Out Test

Description

The purpose of this test is to check the Ref/Sample In and Marker Out ports. An external reference is connected to the Ref/Sample In port and sent to the Marker Out port.

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set up equipment as shown in Figure 2-1:

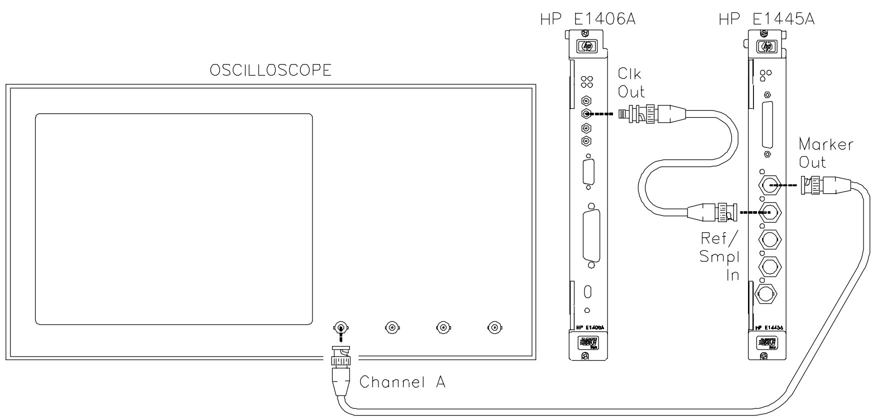


Figure 2-1. Ref/Sample In Test Setup

3. Set up the AFG to output the external reference to the "Marker Out" port:

ROSC:SOUR EXT	*External ref oscillator*
MARK:FEED "ROSC"	*Marker source is ROSC*
INIT:IMM	*Initiate*

4. Verify that the scope shows a 10 MHz squarewave.

Functional Verification: Start Arm In Test

Description

The purpose of this test is to check the Start Arm In port. The "TRIG OUT" port of the Command Module is used to send a Start Arm signal to the AFG.

Test Procedure

1. Reset the AFG:

   *RST;*CLS — *Reset AFG and clear status registers*

2. Set up equipment as shown in Figure 2-2:

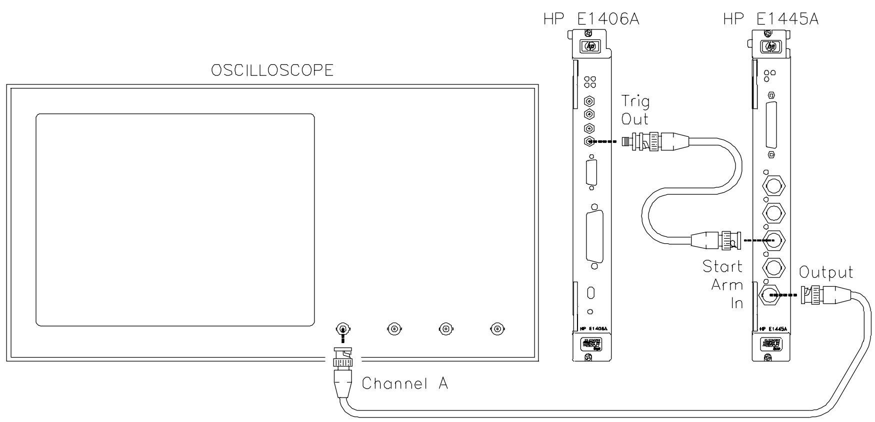


Figure 2-2. Start Arm In Test Setup

3. Send the following commands to the Command Module to output 0 V to the "Trig Out" port:

```
*RST
OUTP:EXT:STAT ON
OUTP:EXT:SOUR INT
OUTP:EXT:LEV 1
```

Test Procedure (cont'd)

4. Set up the AFG to output a 1 MHz sinewave, with an external Start Arm source:

FREQ 1E6;	*Set freq to 1 MHz*
:VOLT 4VPP	*Set AFG amplitude*
ARM:LAY2:SOUR EXT	*External Start Arm source*
INIT:IMM	*Initiate*

5. Verify that no signal appears on the scope. Send the following command to the Command Module to provide a Start Arm signal to the AFG:

```
OUTP:EXT:LEV 0
```

6. Verify that a 1 MHz sinewave appears on the scope.

Functional Verification: Gate In Test

Description

The purpose of this test is to check the gating function. The "TRIG OUT" port of the Command Module is used to gate the output.

Test Procedure

1. Reset the AFG:

   *RST;*CLS — *Reset AFG and clear status registers*

2. Set up the equipment as shown in Figure 2-3.

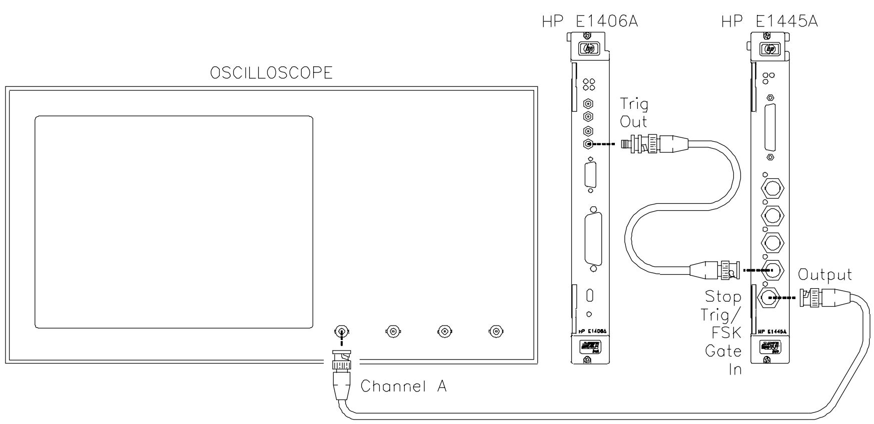


Figure 2-3. Gate In Test Setup

3. Send the following commands to the Command Module to enable the "Trig Out" port:

```
*RST
OUTP:EXT:STAT ON
OUTP:EXT:SOUR INT
```

Test Procedure (cont'd)

4. Set up the AFG to output a 1 MHz sinewave with an external gate source:

TRIG:GATE:SOUR EXT;	*External gate source*
:TRIG:GATE:STAT ON;	*Enable gate*
:FREQ 1E6;	*Set freq to 1 MHz*
:VOLT 4VPP	*Set AFG amplitude*
INIT:IMM	*Initiate*

5. Send the following command to the Command Module to set the level at the "Trig Out" port to 5 V. Verify that the scope shows a 1 MHz sinewave.

```
OUTP:EXT:LEV 0
```

6. Send the following command to the Command Module to set the level at the "Trig Out" port to 0 V. Verify that the scope shows a DC signal.

```
OUTP:EXT:LEV 1
```

Functional Verification: Output Relay Test

Description

The purpose of this test is to check the output relay.

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set up equipment as shown in Figure 2-4:

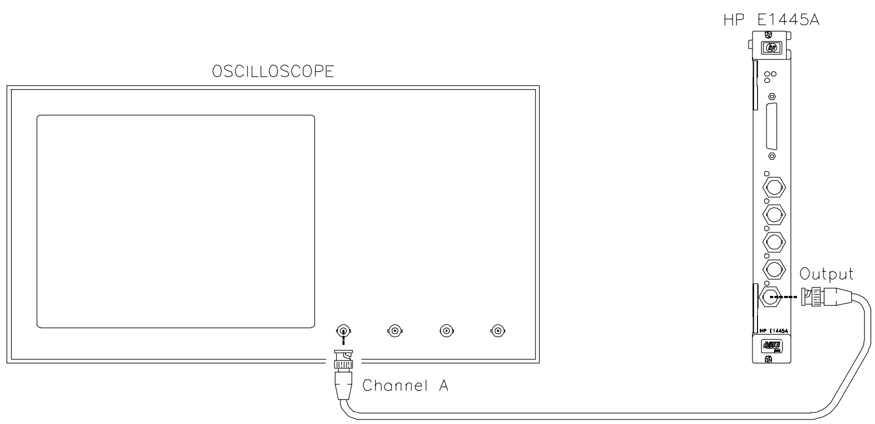


Figure 2-4. Output Relay Test Setup

3. Set up the AFG to output a 1 MHz sinewave:

FREQ 1E6;	*Set freq to 1 MHz*
:VOLT 4VPP	*Set AFG amplitude*
INIT:IMM	*Initiate*

4. Verify that a 1 MHz sinewave appears on the scope.

5. Disable the Output relay:

OUTP OFF

6. Verify that no signal appears on the scope.

Functional Verification

Example Program

This program performs the Functional Verification Tests for the AFG. An Agilent E1405/E1406 Command Module is required for this test.

```
10!   RE-STORE "FUNC_TEST"
20    COM @Afg,@Cmd_mod,INTEGER Done
30    !
40    !---------- Set up I/O paths ----------
50    ASSIGN @Afg TO 70910
60    ASSIGN @Cmd_mod TO 70900
70    !
80    !---------- Initialize AFG & Command Module ----------
90    Reset_afg
100   !
110   !Set up Command Module 'TRIG OUT' port
120   OUTPUT @Cmd_mod;"*RST"
130   OUTPUT @Cmd_mod;"OUTP:EXT:STAT ON"
140   OUTPUT @Cmd_mod;"OUTP:EXT:SOUR INT"
150   !
160   !---------- Perform tests ----------
170   CLEAR SCREEN
180   PRINT "Agilent E1445A FUNCTIONAL VERIFICATION TESTS"
190   PRINT
200   !
210   !Oscilloscope settings
220   PRINT "Set scope to:  2 V/div, .02 usec/div"
230   PRINT
240   Wait_for_cont
250   !
260   CALL Self_test                                  !Self-Test
270   CALL Ref_in                                     !Ref In/Marker Out Test
280   !
290   !Oscilloscope settings
300   CLEAR SCREEN
310   PRINT "Set scope to:  2 V/div, .2 usec/div"
320   PRINT
330   Wait_for_cont
340   !
350   CALL Start_arm                                  !Start Arm In Test
360   CALL Gate_in                                    !Gate In Test
370   CALL Output_relay                               !Output Relay Test
380   !
390 Quit:  !
400   Reset_afg
410   CLEAR SCREEN
420   DISP "Functional Tests completed."
430   END
```

(Continued on next page)

Example Program (cont'd)

```
450  !---------- Subprograms ----------
460  SUB Reset_afg
470    COM @Afg,@Cmd_mod,INTEGER Done
480    OUTPUT @Afg;"*RST;*CLS"                    !Reset AFG and clear Status register
490    WAIT 1
500  SUBEND
510  !
520  SUB Self_test
530    COM @Afg,@Cmd_mod,INTEGER Done
540    DIM Message$[255]
550    !
560    Reset_afg
570    !
580    CLEAR SCREEN
590    PRINT "SELF-TEST"
600    PRINT
610    !
620    !Test connections
630    PRINT "Remove any connections from the E1445A front panel."
640    PRINT "Press 'Continue' to initiate Self-Test."
650    PRINT
660    Wait_for_cont
670    !
680    !Perform test
690    OUTPUT @Afg;"*TST?"                        !Self-test command
700    ENTER @Afg;Result                          !Get result
710    !
720    IF Result=0 THEN
730      PRINT "Self-test passed."
740    ELSE
750      PRINT "Self-test failed."
760      PRINT "The following error(s) occurred:"
770      REPEAT
780        OUTPUT @Afg;"SYST:ERR?"                !Check for errors
790        ENTER @Afg;Message$
800        PRINT "    "&Message$
810      UNTIL POS(Message$,"No error")
820    END IF
830    Wait_for_cont
840  SUBEND
850  !
860  SUB Ref_in
870    COM @Afg,@Cmd_mod,INTEGER Done
880    !
```

(Continued on next page)

Example Program (cont'd)

```
890    Reset_afg
900    !
910    CLEAR SCREEN
920    PRINT "REF IN/MARKER OUT TEST"
930    PRINT
940    !
950    !Test connections
960    PRINT "Connect Scope to 'Marker Out' on the E1445A."
970    PRINT "Connect Command Module 'Clk Out' to 'Ref/Sample In' on the E1445A."
980    PRINT
990    Wait_for_cont
1000    !
1010    !Perform test
1020    OUTPUT @Afg;"ROSC:SOUR EXT"                 !External ref osc source
1030    OUTPUT @Afg;"MARK:FEED ""ROSC"""            !Marker source is 'ROSC'
1040    OUTPUT @Afg;"INIT:IMM"                      !Initiate
1050    !
1060    PRINT "Verify that the scope shows a 10 MHz squarewave."
1070    Wait_for_cont
1080  SUBEND
1090  !
1100  SUB Start_arm
1110    COM @Afg,@Cmd_mod,INTEGER Done
1120    !
1130    Reset_afg
1140    !
1150    CLEAR SCREEN
1160    PRINT "START ARM TEST"
1170    PRINT
1180    !
1190    !Test connections
1200    PRINT "Connect Scope to the E1445A Output."
1210    PRINT "Connect Command Module 'Trig Out' to 'Start Arm In' on the E1445A."
1220    PRINT
1230    Wait_for_cont
1240    !
1250    !Set Command Module's 'TRIG OUT' to 0V (E1405 uses neg logic)
1260    OUTPUT @Cmd_mod;"OUTP:EXT:LEV 1"
1270    !
1280    !Perform test
1290    OUTPUT @Afg;"FREQ 1E6;";                    !Set freq to 1 MHz
1300    OUTPUT @Afg;":VOLT 4VPP"                    !Set amplitude
1310    OUTPUT @Afg;"ARM:LAY2:SOUR EXT"             !Start Arm source is EXT
1320    OUTPUT @Afg;"INIT:IMM"                      !Initiate
1330    !
```

(Continued on next page)

Functional Verification

Example Program (cont'd)

```
1340   PRINT "Verify that no signal appears on the scope."
1350   PRINT "Press 'Continue' to send a START ARM."
1360   PRINT
1370   Wait_for_cont
1380   !
1390   !Set 'TRIG OUT' to 5V
1400   OUTPUT @Cmd_mod;"OUTP:EXT:LEV 0"
1410   !
1420   PRINT "Verify that the scope shows a 1 MHz sinewave."
1430   Wait_for_cont
1440 SUBEND
1450 !
1460 SUB Gate_in
1470   COM @Afg,@Cmd_mod,INTEGER Done
1480   !
1490   Reset_afg
1500   !
1510   CLEAR SCREEN
1520   PRINT "GATE IN TEST"
1530   PRINT
1540   !
1550   !Test connections
1560   PRINT "Connect Scope to the E1445A Output."
1570   PRINT "Connect Command Module 'Trig Out' to 'Stop Trig/FSK/Gate In' on the E1445A."
1580   PRINT
1590   Wait_for_cont
1600   !
1610   !Perform test
1620   OUTPUT @Afg;"TRIG:GATE:SOUR EXT;";            !Gate source is EXT
1630   OUTPUT @Afg;":TRIG:GATE:STAT ON;";            !Enable gate
1640   OUTPUT @Afg;":FREQ 1E6;";                     !Set freq to 1 MHz
1650   OUTPUT @Afg;":VOLT 4VPP"                      !Set amplitude
1660   OUTPUT @Afg;"INIT:IMM"                        !Initiate
1670   !
1680   PRINT "Verify that the signal displayed on the scope toggles between"
1690   PRINT "a 1 MHz sinewave and a DC signal at 1 second intervals."
1700   !
1710   ON KBD ALL CALL Key_press
1720   DISP "Press any key to continue"
1730   !
1740   Done=0
1750   !Send pulses to 'TRIG OUT' BNC until a key is pressed
```

(Continued on next page)

Functional Verification

Example Program (cont'd)

```
1760   REPEAT
1770     OUTPUT @Cmd_mod;"OUTP:EXT:LEV 1"
1780     WAIT 1
1790     OUTPUT @Cmd_mod;"OUTP:EXT:LEV 0"
1800     WAIT 1
1810   UNTIL Done
1820   OFF KBD
1830  SUBEND
1840  !
1850  SUB Output_relay
1860   COM @Afg,@Cmd_mod,INTEGER Done
1870   !
1880   Reset_afg
1890   !
1900   CLEAR SCREEN
1910   PRINT "OUTPUT RELAY TEST"
1920   PRINT
1930   !
1940   !Test connections
1950   PRINT "Connect Scope to the E1445A Output."
1960   PRINT
1970   Wait_for_cont
1980   !
1990   !Perform test
2000   OUTPUT @Afg;"FREQ 1E6;";                        !Set freq to 1 MHz
2010   OUTPUT @Afg;":VOLT 4VPP"                        !Set amplitude
2020   OUTPUT @Afg;"INIT:IMM"                          !Initiate
2030   !
2040   PRINT "Verify that the scope shows a 1 MHz sinewave."
2050   PRINT "Press 'Continue' to disable the E1445A output."
2060   PRINT
2070   Wait_for_cont
2080   !
2090   OUTPUT @Afg;"OUTP OFF"                          !Open Output relay
2100   PRINT "Verify that no signal appears on the scope."
2110   Wait_for_cont
2120  SUBEND
2130  !
```

(Continued on next page)

Example Program (cont’d)

```
2140  SUB Key_press
2150    COM @Afg,@Cmd_mod,INTEGER Done
2160    Done=1
2170    DISP
2180  SUBEND
2190  !
2200  SUB Wait_for_cont
2210    DISP "Press ’Continue’ when ready"
2220    PAUSE
2230    DISP
2240  SUBEND
```

Operation Verification

Operation Verification is a subset of the Performance Verification tests that follow. For the AFG, Operation Verification consists of the following tests:

- DC Accuracy
- AC Accuracy
- Total Harmonic Distortion

Performance Verification

The procedures in this section are used to test the AFG's electrical performance using the specifications in Appendix A of the *Agilent E1445A User's Manual* as the performance standards. These tests are suitable for incoming inspection, troubleshooting, and preventive maintenance. The results of the Performance Verification tests should be recorded in the Performance Test Record (Table 2-11).

Performance Verification includes the following tests:

Test #	Test Name
2-1	DC Zeros
2-2	DC Accuracy
2-3	DC Offset
2-4	AC Accuracy
2-5	AC Flatness - 250 kHz filter
2-6	AC Flatness - 10 MHz filter
2-7	Frequency Accuracy
2-8	Duty Cycle
2-9	Total Harmonic Distortion
2-10	Spurious/Non-harmonic Distortion

Test 2-1: DC Zeros

Description

The purpose of this test is to verify that the AFG meets its specifications for DCV accuracy for an output of zero volts. An arbitrary waveform consisting of zeros is used. The amplitude is varied in order to test each attenuator.

Equipment Setup

- Connect equipment as shown in Figure 2-5
- Set DMM to: DCV, 100 mV range

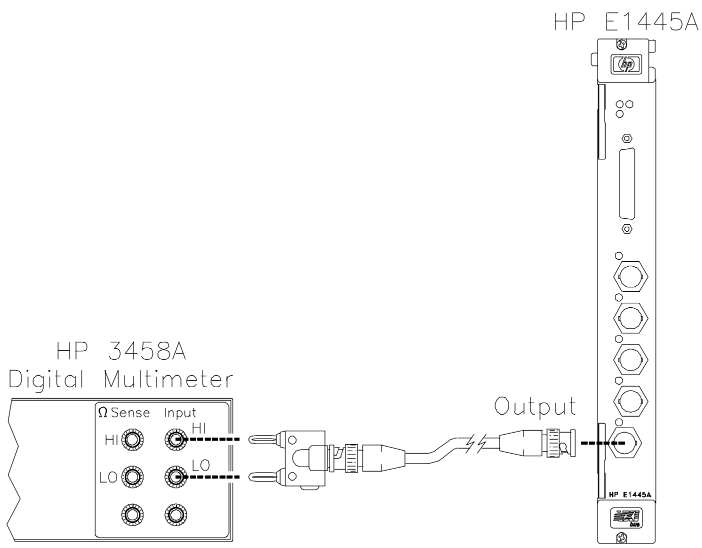


Figure 2-5. Equipment Setup for Test 2-1 thru Test 2-4

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Delete all sequences and segments from memory:

LIST:SSEQ:DEL:ALL	*Delete all sequences*
LIST:SEGM:DEL:ALL	*Delete all segments*

Test Procedure (cont'd)

3. Create a user-defined waveform made up of zeros:

LIST:SEGM:SEL ZEROS	*Select segment name*
LIST:SEGM:DEF 8	*# of segment points*
LIST:SEGM:VOLT 0,0,0,0,0,0,0,0	*Segment list*
LIST:SSEQ:SEL DC_ZEROS	*Select sequence name*
LIST:SSEQ:DEF 1	*# of segments*
LIST:SSEQ:SEQ ZEROS	*Sequence list*

4. Set up the AFG to output the waveform defined above:

ROSC:SOUR CLK10;	*Select 10 MHz clock*
:VOLT MAX;	*Set amplitude*
:OUTP:LOAD INF;	*Infinite load*
:FUNC USER	*Select user waveform*
FUNC:USER DC_ZEROS	*Select sequence*
INIT:IMM	*Initiate waveform*

Perform steps 5 - 7 for each amplitude listed in Table 2-1:

5. Set the AFG output filter as specified in Table 2-1. Use the appropriate command(s) below:

OUTP:FILT OFF	*Disable filter*
or	
OUTP:FILT:FREQ 250KHZ	*Select 250 kHz filter*
OUTP:FILT ON	*Enable filter*
or	
OUTP:FILT:FREQ 10MHZ	*Select 10 MHz filter*
OUTP:FILT ON	*Enable filter*

6. Set the AFG output amplitude:

VOLT *<amplitude>*	*Set amplitude*

where *<amplitude>* is the value specified in Table 2-1.

7. Trigger the DMM and record the reading in Table 2-11.

Test Procedure (cont'd)

Table 2-1. DC Zeros Test Points

Attenuation (dB)	Amplitude (volts)	Filter	Test Limits (volts)
0	10.23750	None	0 ± 0.0220
.99	9.13469	None	0 ± 0.0220
1	9.12416	None	0 ± 0.0220
2	8.13192	None	0 ± 0.0220
4	6.45941	None	0 ± 0.0220
8	4.07560	None	0 ± 0.0220
13	2.29187	None	0 ± 0.0220
14	2.04263	None	0 ± 0.0044
30	0.32372	None	0 ± 0.0044
0	10.23750	250 kHz	0 ± 0.0220
.99	9.13469	250 kHz	0 ± 0.0220
1	9.12416	250 kHz	0 ± 0.0220
2	8.13192	250 kHz	0 ± 0.0220
4	6.45941	250 kHz	0 ± 0.0220
8	4.07560	250 kHz	0 ± 0.0220
13	2.29187	250 kHz	0 ± 0.0220
14	2.04263	250 kHz	0 ± 0.0044
30	0.32372	250 kHz	0 ± 0.0044
0	10.23750	10 MHz	0 ± 0.0220
.99	9.13469	10 MHz	0 ± 0.0220
1	9.12416	10 MHz	0 ± 0.0220
2	8.13192	10 MHz	0 ± 0.0220
4	6.45941	10 MHz	0 ± 0.0220
8	4.07560	10 MHz	0 ± 0.0220
13	2.29187	10 MHz	0 ± 0.0220
14	2.04263	10 MHz	0 ± 0.0044
30	0.32372	10 MHz	0 ± 0.0044

Example Program

This program performs the DC Zeros test. An arbitrary waveform, consisting of zeros, is used with various amplitudes to test a variety of attenuator and filter combinations.

```
10!  RE-STORE "DC_ZEROS"
20   COM @Afg
30   DIM Attn(1:9),Vout(1:9)
40   !
50   !---------- Set up I/O path and reset AFG ----------
60   ASSIGN @Afg TO 70910
70   OUTPUT @Afg;"*RST;*CLS"                        !Reset AFG
80   !
90   !---------- Initialize variables ----------
100  DATA 0,.99,1,2,4,8,13,14,30
110  READ Attn(*)                                   !Read in attenuations
120  !
130  DATA 10.2375,9.13469,9.12416,8.13192,6.45941,4.0756
140  DATA 2.29187,2.04263,0.32372
150  READ Vout(*)
160  !
170  !---------- Set up DMM ----------
180  PRINT "Set up DMM:"
190  PRINT
200  PRINT "     Function --  DCV"
210  PRINT "     Range --  100 mV"
220  PRINT
230  PRINT "Connect DMM HI and LO to AFG Output."
240  DISP "Press 'Continue' when ready"
250  PAUSE
260  CLEAR SCREEN
270  !
280  !---------- Set up AFG ----------
290  OUTPUT @Afg;"*RST"                             !Reset AFG
300  OUTPUT @Afg;"LIST:SSEQ:DEL:ALL"                !Delete all sequences
310  OUTPUT @Afg;"LIST:SEGM:DEL:ALL"                !Delete all segments
320  WAIT .5
330  OUTPUT @Afg;"ROSC:SOUR CLK10;";                !10MHZ clock
340  OUTPUT @Afg;":VOLT MAX;";                      !MAX output
350  OUTPUT @Afg;":OUTP:LOAD INF;";                 !Infinite load
360  OUTPUT @Afg;":FUNC USER"                       !User waveform
370  !
380  CALL Def_seq_zeros                             !Define waveform
390  OUTPUT @Afg;"FUNC:USER DC_ZEROS"               !Select sequence
400  OUTPUT @Afg;"INIT:IMM"
410  !
420  !---------- Perform test ----------
430  PRINT "ATTEN","FILTER","AMPLITUDE"
```

(Continued on next page)

Test 2-1: DC Zeros (cont’d)

Example Program (cont’d)

```
440  PRINT
460  FOR Filter=0 TO 2
470    SELECT Filter
480    CASE 0                                       !No filter
490      OUTPUT @Afg;"OUTP:FILT OFF"
500      Filter$="NONE"
510    CASE 1                                       !250KHZ filter
520      OUTPUT @Afg;"OUTP:FILT:FREQ 250KHZ"
530      OUTPUT @Afg;"OUTP:FILT ON"
540      Filter$="250 kHz"
550    CASE 2                                       !10MHZ filter
560      OUTPUT @Afg;"OUTP:FILT:FREQ 10MHZ"
570      OUTPUT @Afg;"OUTP:FILT ON"
580      Filter$="10 MHz"
590    END SELECT
600    !
610    FOR I=1 TO 9                                 !Loop through atten’s
620      OUTPUT @Afg;":VOLT "&VAL$(Vout(I))         !Set AFG amplitude
630      PRINT Attn(I),Filter$,Vout(I)
640      !
650      DISP "Record DMM reading, then press ’Continue’"
660      PAUSE
670      DISP
680    NEXT I                                       !Next attenuation
690    PRINT
700  NEXT Filter                                    !Next filter
710  !
720  OUTPUT @Afg;"*RST;*CLS"                        !Reset AFG
730  END
740  !
750  SUB Def_seq_zeros
760    COM @Afg
770    OUTPUT @Afg;"LIST:SEGM:SEL ZEROS"            !Segment name
780    OUTPUT @Afg;"LIST:SEGM:DEF 8"                !Segment length
790    OUTPUT @Afg;"LIST:SEGM:VOLT 0,0,0,0,0,0,0,0" !Voltage points
800    !
810    OUTPUT @Afg;"LIST:SSEQ:SEL DC_ZEROS"         !Sequence name
820    OUTPUT @Afg;"LIST:SSEQ:DEF 1"                !# of segments
830    OUTPUT @Afg;"LIST:SSEQ:SEQ ZEROS"            !Segment list
840  SUBEND
```

Test 2-2: DC Accuracy

Description

The purpose of this test is to verify that the AFG meets its specifications for DC accuracy.

Equipment Setup

- Connect equipment as shown in Figure 2-5
- Set DMM to DCV, autorange

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set up the AFG to output a DC signal:

FUNC DC;	*Select DC waveform*
:OUTP:LOAD INF;	*Infinite load*
:VOLT MAX	*Set amplitude*

Perform steps 3 - 5 for each amplitude listed in Table 2-2:

3. Set up the AFG output filter as specified in Table 2-2. Use the appropriate command(s) below:

OUTP:FILT OFF	*Disable filter*
or	
OUTP:FILT:FREQ 250KHZ	*Select 250 kHz filter*
OUTP:FILT ON	*Enable filter*
or	
OUTP:FILT:FREQ 10MHZ	*Select 10 MHz filter*
OUTP:FILT ON	*Enable filter*

4. Set the AFG output amplitude:

VOLT *<amplitude>*	*Set amplitude*

   where *<amplitude>* is the value specified in Table 2-2.

5. Trigger the DMM and record the reading.

Test 2-2: DC Accuracy (cont'd)

Test Procedure (cont'd)

Table 2-2. DC Accuracy Test Points

Amplitude (volts)	Filter	Test Limits (volts)
10.2375	None	10.2375 ± 0.0512
5.0	None	5.0 ± 0.0355
0.0	None	0.0 ± 0.0205
-5.0	None	-5.0 ± 0.0355
-10.24	None	-10.24 ± 0.0512
10.2375	250 kHz	10.2375 ± 0.0512
-10.24	250 kHz	-10.24 ± 0.0512
10.2375	10 MHz	10.2375 ± 0.0512
-10.24	10 MHz	-10.24 ± 0.0512
		10.24 ± 0.0512

Example Program

This program performs the DC Accuracy test.

```
10!   RE-STORE "DC_LEVELS"
20    DIM Vout(1:9),Filter(1:9)
30    !
40    !---------- Set up I/O path and reset AFG -----------
50    ASSIGN @Afg TO 70910
60    OUTPUT @Afg;"*RST;*CLS"                              !Reset AFG
70    !
80    !---------- Initialize variables ----------
90    DATA 10.2375,5.0,0,-5.0,-10.24,10.2375,-10.24,10.2375,-10.24
100   READ Vout(*)
110   !
120   DATA 0,0,0,0,0,1,1,2,2
130   READ Filter(*)
140   !
150   !---------- Set up DMM ----------
160   CLEAR SCREEN
170   PRINT "Set up DMM:"
180   PRINT
190   PRINT "     Function -- DCV"
200   PRINT "     Range -- AUTO"
210   PRINT
220   PRINT "Connect DMM HI and LO to AFG Output."
230   DISP "Press 'Continue' when ready"
240   PAUSE
250   CLEAR SCREEN
```

Example Program (cont'd)

```
270  !---------- Set up AFG ----------
280  OUTPUT @Afg;"*RST"                          !Reset AFG
290  WAIT .5
300  OUTPUT @Afg;"FUNC DC;";                     !DC function
310  OUTPUT @Afg;":OUTP:LOAD INF;";              !Infinite load
320  OUTPUT @Afg;":VOLT MAX"                     !MAX output
330  !
340  !---------- Perform test ----------
350  PRINT "FILTER","AMPLITUDE"
360  PRINT
370  !
380  FOR I=1 TO 9
390    SELECT Filter(I)
400    CASE 0
410      OUTPUT @Afg;"OUTP:FILT OFF"             !No filter
420      Filter$="NONE"
430    CASE 1
440      OUTPUT @Afg;"OUTP:FILT:FREQ 250KHZ"     !250kHz filter
450      OUTPUT @Afg;"OUTP:FILT ON"
460      Filter$="250 kHz"
470    CASE 2
480      OUTPUT @Afg;"OUTP:FILT:FREQ 10MHZ"      !10MHz filter
490      OUTPUT @Afg;"OUTP:FILT ON"
500      Filter$="10 MHz"
510    END SELECT
520    !
530    OUTPUT @Afg;"VOLT "&VAL$(Vout(I))         !Set amplitude
540    PRINT Filter$,Vout(I)
550    !
560    DISP "Record DMM reading, then press 'Continue'"
570    PAUSE
580    DISP
590  NEXT I
600  !
610  OUTPUT @Afg;"*RST;*CLS"                     !Reset AFG
620  END
```

Test 2-3: DC Offset

Description

The purpose of this test is to verify that the AFG meets its specifications for DC offset accuracy.

Equipment Setup

- Connect equipment as shown in Figure 2-5
- Set DMM to DCV, autorange

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Delete all sequences and segments from memory:

LIST:SSEQ:DEL:ALL	*Delete all sequences*
LIST:SEGM:DEL:ALL	*Delete all segments*

3. Create a user-defined waveform made up of zeros:

LIST:SEGM:SEL ZEROS	*Select segment name*
LIST:SEGM:DEF 8	*# of segment points*
LIST:SEGM:VOLT 0,0,0,0,0,0,0,0	*Segment list*
LIST:SSEQ:SEL DC_ZEROS	*Select sequence name*
LIST:SSEQ:DEF 1	*# of segments*
LIST:SSEQ:SEQ ZEROS	*Sequence list*

4. Set up the AFG to output the waveform defined above:

ROSC:SOUR CLK10;	*Select 10 MHz clock*
:OUTP:LOAD INF;	*Infinite load*
:VOLT MAX;	*Set amplitude*
:FUNC USER	*Select user waveform*
FUNC:USER DC_ZEROS	*Select sequence*
INIT:IMM	*Initiate waveform*

Test Procedure (cont'd)

Perform steps 5 - 7 for each offset listed in Table 2-3:

5. If necessary, change the AFG output amplitude:

```
VOLT:OFFS 0;              Set offset to 0
:VOLT <amplitude>         Set amplitude
```

where <*amplitude*> is the value specified in Table 2-3.

6. Set AFG offset voltage:

```
VOLT:OFFS <offset>        Set offset
```

where <*offset*> is the value specified in Table 2-3.

7. Trigger the DMM and record the reading.

Table 2-3. DC Offset Test Points

Offset (volts)	Amplitude (volts)	Test Limits (volts)
9.755	2.29189	9.755 ± 0.1196
4.000	2.29189	4.0 ± 0.0620
-4.000	2.29189	-4.0 ± 0.0620
-9.755	2.29189	-9.755 ± 0.1196
2.000	0.40756	2.0 ± 0.0244
-2.000	0.40756	-2.0 ± 0.0244

Example Program

This program performs the DC Offset Test.

```
10!   RE-STORE "DC_OFFSET"
20    COM @Afg
30    DIM Offset(1:6)
40    !
50    !---------- Set up I/O path and reset AFG ----------
60    ASSIGN @Afg TO 70910                            !AFG I/O path
70    OUTPUT @Afg;"*RST;*CLS"                         !Reset AFG
80    !
90    !---------- Initialize variables ----------
100   DATA 9.755,4.0,-4.0,-9.755,2.0,-2.0
110   READ Offset(*)                                  !Read in offsets
120   !
130   Vout_old=0                                      !Initialize
140   !
150   !---------- Set up DMM ----------
160   CLEAR SCREEN
170   PRINT "Set up DMM:"
180   PRINT
190   PRINT "     Function -- DCV"
200   PRINT "     Range -- AUTO"
210   PRINT
220   PRINT "Connect DMM HI and LO to AFG Output."
230   DISP "Press 'Continue' when ready"
240   PAUSE
250   CLEAR SCREEN
260   !
270   !---------- Set up AFG ----------
280   OUTPUT @Afg;"*RST"                              !Reset AFG
290   OUTPUT @Afg;"LIST:SSEQ:DEL:ALL"                 !Delete all sequences
300   OUTPUT @Afg;"LIST:SEGM:DEL:ALL"                 !Delete all segments
310   WAIT .5
320   OUTPUT @Afg;"ROSC:SOUR CLK10;";                 !10MHz clock
330   OUTPUT @Afg;":OUTP:LOAD INF;";                  !Infinite load
340   OUTPUT @Afg;":VOLT MAX;";                       !MAX output
350   OUTPUT @Afg;":FUNC USER"                        !User waveform
360   !
370   CALL Def_seq_zeros                              !Define sequence of zeros
380   OUTPUT @Afg;"FUNC:USER DC_ZEROS"                !Select sequence
390   !
400   !---------- Perform test ----------
410   PRINT "AMPLITUDE"," OFFSET"
420   PRINT
430   !
```

(Continued on next page)

Example Program (cont'd)

```
440  FOR I=1 TO 6
450     IF I<=4 THEN
460        Vout=2.2919
470     ELSE
480        Vout=.40756
490     END IF
500     !
510     IF Vout<>Vout_old THEN
520        !Set offset to zero before changing amplitude
530        OUTPUT @Afg;":VOLT:OFFS 0;";
540        OUTPUT @Afg;":VOLT "&VAL$(Vout)&";";
550     END IF
560     !
570     OUTPUT @Afg;":VOLT:OFFS "&VAL$(Offset(I))!Set offset
580     PRINT Vout,Offset(I)
590     !
600     DISP "Record DMM reading, then press 'Continue'"
610     PAUSE
620     DISP
630     Vout_old=Vout
640  NEXT I                                          !Next attenuation
650  !
660  OUTPUT @Afg;"*RST;*CLS"                         !Reset AFG
670  END
680  !
690  SUB Def_seq_zeros
700     COM @Afg
710     OUTPUT @Afg;"LIST:SEGM:SEL ZEROS"            !Segment name
720     OUTPUT @Afg;"LIST:SEGM:DEF 8"                !Segment length
730     OUTPUT @Afg;"LIST:SEGM:VOLT 0,0,0,0,0,0,0,0" !Voltage points
740     !
750     OUTPUT @Afg;"LIST:SSEQ:SEL DC_ZEROS"         !Sequence name
760     OUTPUT @Afg;"LIST:SSEQ:DEF 1"                !# of segments
770     OUTPUT @Afg;"LIST:SSEQ:SEQ ZEROS"            !Segment list
780  SUBEND
```

Test 2-4: AC Accuracy

Description

The purpose of this test is to verify that the AFG meets its specifications for AC accuracy at 1 kHz.

Equipment Setup

- Connect equipment as shown in Figure 2-5
- Set DMM to ACV, autorange

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set up the AFG to output a 1 kHz sinewave:

FREQ 1E3;	*Set freq to 1 kHz*
:VOLT MAX;	*Set to max amplitude*
:OUTP:LOAD INF	*Infinite load*
CAL:STAT:AC OFF	*AC corrections off*
INIT:IMM	*Initiate waveform*

Perform steps 3 - 5 for each amplitude and filter listed in Table 2-4:

3. Set up AFG output filter as specified in Table 2-4. Use the appropriate command(s) below:

OUTP:FILT OFF	*Disable filter*
or	
OUTP:FILT:FREQ 250KHZ	*Select 250 kHz filter*
OUTP:FILT ON	*Enable filter*
or	
OUTP:FILT:FREQ 10MHZ	*Select 10 MHz filter*
OUTP:FILT ON	*Enable filter*

Test Procedure (cont'd)

4. Set the AFG output amplitude:

   VOLT <*amplitude*>VRMS — *Set amplitude*

   where <*amplitude*> is the value specified in Table 2-4.

5. Trigger the DMM and record the reading.

Table 2-4. AC Accuracy Test Points

Amplitude (volts rms)	Filter	Test Limits ±(dB)
7.2390	None	0.10
6.4500	None	0.15
5.7500	None	0.15
4.5660	None	0.15
2.8818	None	0.15
1.4444	None	0.15
0.2290	None	0.15
7.2390	250 kHz	0.10
7.2390	10 MHz	0.10

Example Program

This program performs the AC Accuracy Test.

```
10!   RE-STORE "AC_LEVELS"
20    DIM Vout(1:9),Filter(1:9)
30    !
40    !---------- Set up I/O path and reset AFG ----------
50    ASSIGN @Afg TO 70910
60    OUTPUT @Afg;"*RST;*CLS"                          !Reset AFG
70    !
80    !---------- Initialize variables ----------
90    DATA 7.239,6.45,5.75,4.566,2.8818,1.4444,.229,7.239,7.239
100   READ Vout(*)
110   !
120   DATA 0,0,0,0,0,0,0,1,2
130   READ Filter(*)
140   !
150   !---------- Set up DMM ----------
160   CLEAR SCREEN
170   PRINT "Set up DMM:"
180   PRINT
190   PRINT "     Function -- ACV"
200   PRINT "     Range -- AUTO"
210   PRINT
220   PRINT "Connect DMM HI and LO to AFG Output."
230   DISP "Press 'Continue' when ready"
240   PAUSE
250   CLEAR SCREEN
260   !
270   !---------- Set up AFG ----------
280   OUTPUT @Afg;"*RST"                               !Reset AFG
290   WAIT .5
300   OUTPUT @Afg;"FREQ 1E3;";                         !Set freq to 1 kHz
310   OUTPUT @Afg;":VOLT MAX;";                        !MAX amplitude
320   OUTPUT @Afg;":OUTP:LOAD INF"                     !Infinite load
340   OUTPUT @Afg;"CAL:STAT:AC OFF"                    !AC corrections off
350   OUTPUT @Afg;"INIT:IMM"                           !Initiate
360   WAIT .5
370   !
380   !---------- Perform test ----------
390   PRINT "FILTER","AMPLITUDE"
400   PRINT
410   !
```

(Continued on next page)

Example Program (cont’d)

```
420  FOR I=1 TO 9
430    SELECT Filter(I)
440    CASE 0
450      OUTPUT @Afg;"OUTP:FILT OFF"                 !No filter
460      Filter$="NONE"
470    CASE 1
480      OUTPUT @Afg;"OUTP:FILT:FREQ 250KHZ"         !250 kHz filter
490      OUTPUT @Afg;"OUTP:FILT ON"
500      Filter$="250 kHz"
510    CASE 2
520      OUTPUT @Afg;"OUTP:FILT:FREQ 10MHZ"          !10 MHz filter
530      OUTPUT @Afg;"OUTP:FILT ON"
540      Filter$="10 MHz"
550    END SELECT
560    OUTPUT @Afg;":VOLT "&VAL$(Vout(I))&"VRMS"     !Set amplitude
570    PRINT Filter$,Vout(I)
580    WAIT .5
590    !
600    DISP "Record DMM reading, then press ’Continue’"
610    PAUSE
620    DISP
630  NEXT I
640  !
650  OUTPUT @Afg;"*RST;*CLS"                         !Reset AFG
660  END
```

Test 2-5: AC Flatness - 250 kHz Filter

Description

The purpose of this test is to verify that the AFG meets its specifications for AC flatness with the 250 kHz filter enabled.

Equipment Setup

- Connect equipment as shown in Figure 2-6
- Set DMM to ACV, autorange

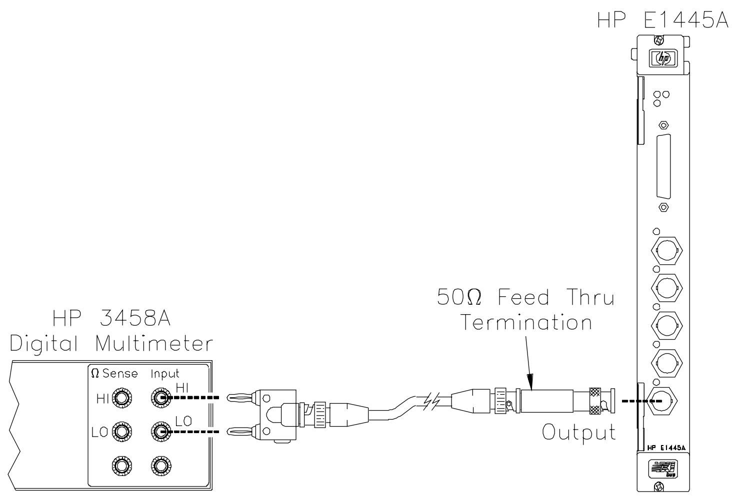


Figure 2-6. Equipment Setup for Test 2-5 and Test 2-6

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set up the AFG to output a 24 dBm sinewave with the 250 kHz filter enabled:

VOLT 24DBM;	*Set amplitude*
:OUTP:LOAD 50	*50 ohm load*
OUTP:FILT:FREQ 250KHZ	*250 kHz filter*
OUTP:FILT ON	*Enable filter*
INIT:IMM	*Initiate waveform*

Test Procedure (cont'd)

3. Set the AFG output to the reference frequency (1 kHz):

   FREQ 1000 — *Set frequency*

4. Measure the amplitude with the DMM and convert the reading to dBm. Note the result for use in step 6:

   $$\text{Reference Level (dBm)} = 20 \times \log \left|\text{Reading (volts)}\right| + 13.0103$$

Perform steps 5 - 6 for each frequency listed in Table 2-5:

5. Set the AFG output:

   FREQ *<frequency>* — *Set frequency*

   where *<frequency>* is the value specified in Table 2-5.

6. Measure the amplitude with the DMM and convert the reading to dBm. Calculate and record the error relative to the reference level calculated in step 4:

   $$\text{Reading (dBm)} = 20 \times \log \left|\text{Reading (volts)}\right| + 13.0103$$

   $$\text{Error (dB)} = \text{Reading (dBm)} - \text{Reference Level (dBm)}$$

Test Procedure (cont'd)

Table 2-5. AC Flatness Test Points - 250 kHz Filter

Frequency (Hz)	Test Limits* ±(dB error)
10E3	0.05 dB
20E3	0.05 dB
30E3	0.05 dB
40E3	0.05 dB
50E3	0.05 dB
60E3	0.05 dB
70E3	0.05 dB
80E3	0.05 dB
90E3	0.05 dB
100E3	0.05 dB
110E3	0.10 dB
120E3	0.10 dB
130E3	0.10 dB

Frequency (Hz)	Test Limits* ±(dB error)
140E3	0.10 dB
150E3	0.10 dB
160E3	0.10 dB
170E3	0.10 dB
180E3	0.10 dB
190E3	0.10 dB
200E3	0.10 dB
210E3	0.10 dB
220E3	0.10 dB
230E3	0.10 dB
240E3	0.10 dB
250E3	0.10 dB

* Error relative to 1 kHz

Example Program

See the AC Flatness Adjustment procedure (Chapter 3) for an example program that performs the AC Flatness Test (change line 180 to: `Mode$="M"`).

Test 2-6: AC Flatness - 10 MHz Filter

Description

The purpose of this test is to verify that the AFG meets its specifications for AC flatness with the 10 MHz filter enabled.

Equipment Setup

- Connect equipment as shown in Figure 2-6
- Set DMM to ACV, autorange

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set up the AFG to output a 24 dBm sinewave with the 10 MHz filter enabled:

VOLT 24DBM;	*Set amplitude*
:OUTP:LOAD 50	*50 ohm load*
OUTP:FILT:FREQ 10MHZ	*10 MHz filter*
OUTP:FILT ON	*Enable filter*
INIT:IMM	*Initiate waveform*

3. Set AFG output to the reference frequency (1 kHz):

FREQ 1000	*Set frequency*

4. Measure the amplitude with the DMM, convert the reading to dBm, and note the reading for future reference:

$$\text{Reference Level (dBm)} = 20 \times \log \left|\text{Reading (volts)}\right| + 13.0103$$

5. Set the AFG to the crossover frequency (lowest frequency that the Power Meter can measure):

FREQ 1E5	*Set frequency*

6. Measure the amplitude with the DMM and note the reading for future reference.

Test Procedure (cont'd)

7. Set up the Power Meter:

   Units - Watts
   Power Range - auto
   Reference Oscillator - ON

NOTE *Follow the Power Meter manufacturer's instructions for performing an autocalibration and correcting for the power sensor.*

8. Connect the equipment as shown in Figure 2-7:

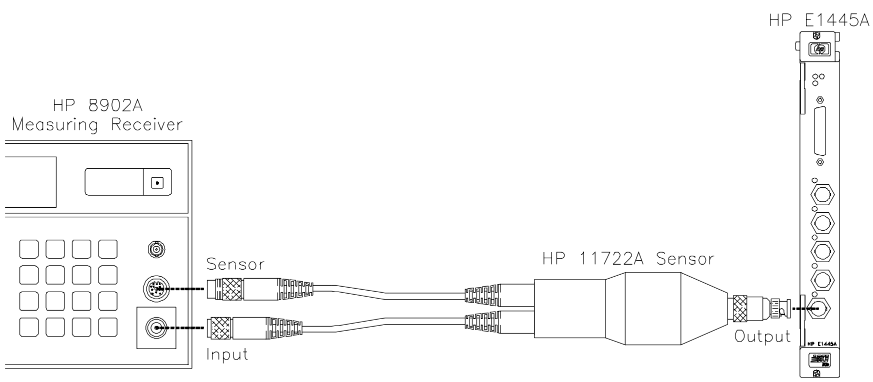


Figure 2-7. Equipment Setup for Test 2-6

9. Set the Power Meter expected frequency to the crossover frequency (100 kHz). Measure the AFG output power and convert the reading to volts:

$$\text{Reading (volts)} = \left(\sqrt{|\text{Reading (watts)}| \times 50}\right)$$

Test Procedure (cont'd)

10. Calculate the correction factor that will be used to reference the Power Meter to the DMM:

$$\text{Correction Factor} = \frac{\text{DMM reading at 100 kHz (step 6)}}{\text{Power Meter reading at 100 kHz (step 9)}}$$

Repeat 11 - 14 for each frequency in Table 2-6:

11. Set the AFG output to the frequency specified in Table 2-6. If the frequency is less than 10.8 MHz, use the following command:

    FREQ *<frequency>*

    where *<frequency>* is the value specified in Table 2-6. If the frequency is 10.8 MHz, use the following register commands to set the output frequency:

```
DIAG:POKE #HE000A1,8,0
DIAG:POKE #HE000A3,8,126
DIAG:POKE #HE000A5,8,95
DIAG:POKE #HE000A7,8,64
DIAG:POKE #HE0008D,8,0
```

12. Set the Power Meter expected frequency to the AFG output frequency.

13. Measure the amplitude with the Power Meter, convert the reading to volts, and multiply by the correction factor.

$$\text{Reading (volts)} = \left(\sqrt{|\text{Reading (watts)}| \times 50}\right)$$

$$\text{Corrected Reading (volts)} = \text{Reading (volts)} \times \text{C.F. (step 10)}$$

14. Convert the reading to dBm. Calculate and record the error relative to the reference level calculated in step 4:

$$\text{Reading (dBm)} = 20 \times \log|\text{Corrected Reading (volts)}| + 13.0103$$

$$\text{Error (dB)} = \text{Reading (dBm)} - \text{Reference Level (dBm)}$$

Test 2-6: AC Flatness - 10 MHz Filter (cont'd)

Test Procedure (cont'd)

Table 2-6. AC Flatness Test Points - 10 MHz Filter

Frequency (Hz)	Test Limits* ±(dB error)	Frequency (Hz)	Test Limits* ±(dB error)
400E3	0.2 dB	6.0E6	0.2 dB
800E3	0.2 dB	6.4E6	0.2 dB
1.2E6	0.2 dB	6.8E6	0.2 dB
1.6E6	0.2 dB	7.2E6	0.2 dB
2.0E6	0.2 dB	7.6E6	0.2 dB
2.4E6	0.2 dB	8.0E6	0.2 dB
2.8E6	0.2 dB	8.4E6	0.2 dB
3.2E6	0.2 dB	8.8E6	0.2 dB
3.6E6	0.2 dB	9.2E6	0.2 dB
4.0E6	0.2 dB	9.6E6	0.2 dB
4.4E6	0.2 dB	10.0E6	0.2 dB
4.8E6	0.2 dB	10.4E6	0.2 dB
5.2E6	0.2 dB	10.8E6	0.2 dB
5.6E6	0.2 dB		

* Error relative to 1 kHz

Example Program

See the AC Flatness Adjustment procedure (Chapter 3) for an example program that performs the AC Flatness Test (change line 180 to: Mode$="M").

Test 2-7: Frequency Accuracy

Description

The purpose of this test is to verify that the AFG meets its specifications for frequency accuracy.

Equipment Setup

- Connect equipment as shown in Figure 2-8
- Set Counter to: Frequency, 50Ω input impedance

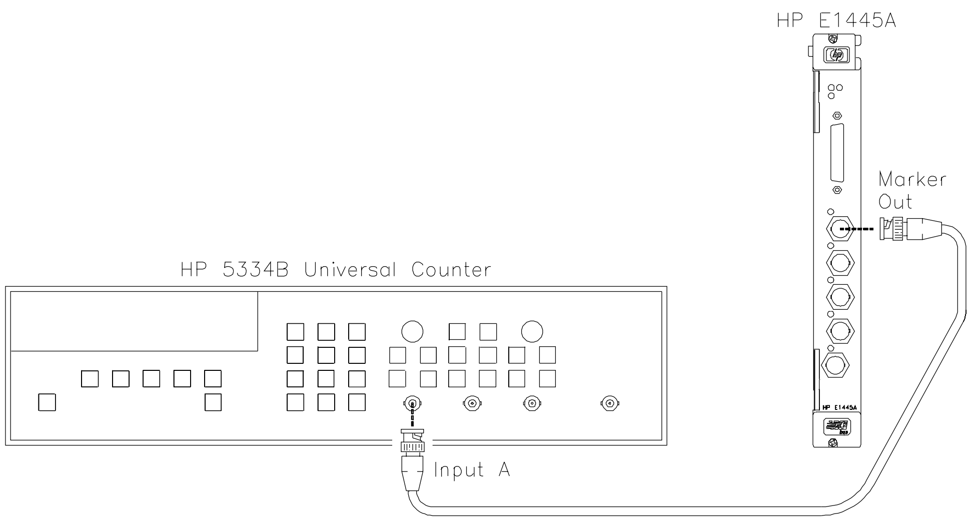


Figure 2-8. Equipment Setup for Test 2-7

Test Procedure

1. Reset the AFG:

   *RST;*CLS — *Reset AFG and clear status registers*

Perform steps 2 - 6 for each entry listed in Table 2-7:

2. Abort the waveform if it has been previously initiated:

   ABORT

Test Procedure (cont'd)

3. Set reference oscillator to INT1 or INT2, as specified in Table 2-7:

ROSC:SOUR INT1	*Set ref osc to INT1*
or	
ROSC:SOUR INT2	*Set ref osc to INT2*

4. Set marker source to "ROSC" or "TRIG", as specified in Table 2-7:

MARK:FEED "ROSC"	*Set marker source to "ROSC"*
or	
MARK:FEED "TRIG"	*Set marker source to "TRIG"*

5. If the marker source is "TRIG", use the following commands to output a squarewave (otherwise, skip this step):

FUNC SQU;	*Select squarewave*
:FREQ2 *<frequency>*;	*Set AFG frequency*
:TRIG:SOUR INT2	*Set trig source*
INIT:IMM	*Initiate*

where *<frequency>* is the value given in the "Squarewave Frequency" column of Table 2-7.

NOTE *If the marker source is "TRIG", the marker output frequency will be four times the frequency of the squarewave, since it takes four points to produce a squarewave. See Table 2-7 for the expected frequencies.*

6. Measure frequency with the Counter and record the reading in Table 2-11.

Test Procedure (cont’d)

Table 2-7. Frequency Accuracy Test Points

Ref Oscillator Source	Marker Source	Squarewave Frequency (Hz)	Test Limits (Hz)*
INT1	"ROSC"	----------	42.94967 E6 ± 0.005%
INT2	"ROSC"	----------	40 E6 ± 0.005%
INT2	"TRIG"	5.0 E6	20 E6 ± 0.005%
INT2	"TRIG"	3.333 E3	13.3333 E6 ± 0.005%
INT2	"TRIG"	76.294	305.176 ± 0.005%

*Add aging rate of ±20 ppm/year

Example Program

This program performs the Frequency Accuracy Test.

```
10!   RE-STORE "OSC_FREQ"
20    DIM Freq(1:5)
30    !
40    !---------- Set up I/O path and reset AFG ----------
50    ASSIGN @Afg TO 70910
60    OUTPUT @Afg;"*RST;*CLS"                          !Reset AFG
70    !
80    !---------- Initialize variables ----------
90    DATA 42.94967E6,40E6,20E6,13.3333E6,305.176
100   READ Freq(*)
110   !
120   !---------- Set up Counter ----------
130   CLEAR SCREEN
140   PRINT "Set up Counter:"
150   PRINT
160   PRINT "     Function -- Frequency"
170   PRINT "     Input Impedance -- 50 ohms"
180   PRINT
190   PRINT "Connect the Counter to ’Marker Out’ on the E1445A."
200   PRINT
210   DISP "Press ’Continue’"
220   PAUSE
230   CLEAR SCREEN
240   !
```

(Continued on next page)

Example Program (cont’d)

```
250  !---------- Set up AFG ----------
260  OUTPUT @Afg;"*RST"                            !Reset AFG
270  WAIT .5
280  !
290  !---------- Perform test ----------
300  FOR I=1 TO 5
310    PRINT "Expected reading =";Freq(I)
320    PRINT
330    IF I=1 THEN
340      OUTPUT @Afg;"ROSC:SOUR INT1"              !ROSC = INT1
350      OUTPUT @Afg;"MARK:FEED ""ROSC"""          !Marker source = ROSC
360    ELSE
370      OUTPUT @Afg;"ABORT"                       !Abort waveform
380      OUTPUT @Afg;"ROSC:SOUR INT2"              !ROSC = INT2
390      IF Freq(I)=4.0E+7 THEN
400        OUTPUT @Afg;"MARK:FEED ""ROSC"""        !Marker source = ROSC
410      ELSE
420        OUTPUT @Afg;":FUNC SQU;";               !Squarewave
430        !
440        !Square wave freq is 1/4 of marker freq
450        OUTPUT @Afg;":FREQ2 "&VAL$(Freq(I)/4)&";";
460        OUTPUT @Afg;":TRIG:STAR:SOUR INT2"!TRIG source = INT2
470        OUTPUT @Afg;"MARK:FEED ""TRIG"""        !Marker source = TRIG
480      END IF
490    END IF
500    !
510    OUTPUT @Afg;"INIT:IMM"                      !Initiate
520    WAIT 1
530    !
540    DISP "Record the Counter reading, then press ’Continue’"
550    PAUSE
560    DISP
570  NEXT I
580  !
590  OUTPUT @Afg;"*RST;*CLS"                       !Reset AFG
600  END
```

Test 2-8: Duty Cycle

Description

The purpose of this test is to verify that the AFG meets its specifications for square wave duty cycle. Duty cycle is determined by measuring positive pulse width.

Equipment Setup

- Connect equipment as shown in Figure 2-9
- Set Counter to: Pulse Width, DC coupling, 50Ω input impedance

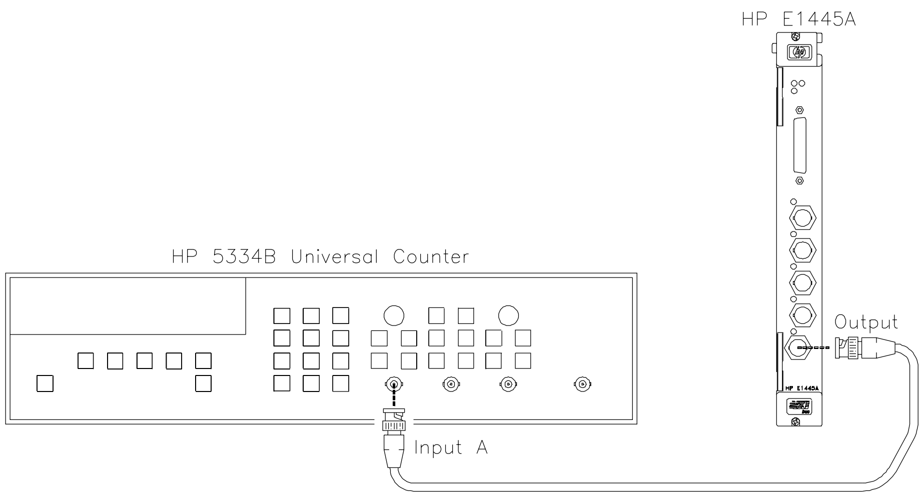


Figure 2-9. Equipment Setup for Test 2-8

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set the AFG to output a square wave:

FUNC SQU;	*Select squarewave*
:VOLT MAX	*Set to max amplitude*

Perform steps 3 - 7 for each frequency listed in Table 2-8:

3. Abort the waveform if it has been previously initiated:

```
ABORT
```

Test Procedure (cont'd)

4. Set the AFG frequency range as specified in Table 2-8:

   FREQ:RANG MAX — *Enable doubling*
   or
   FREQ:RANG MIN — *Disable doubling*

5. Set AFG output frequency:

   FREQ *<frequency>* — *Set frequency*

   where *<frequency>* is the value specified in Table 2-8.

6. Initiate the waveform:

   INIT:IMM

7. Measure positive pulse width (average at least 10 periods) with the Counter and record the reading in Table 2-11.

NOTE *If a percentage result is desired, measure the period (average at least 10 periods.* ***Duty Cycle (%) = 100 x (Positive Pulse Width/Period)***

Table 2-8. Duty Cycle Test Points

Frequency (Hz)	Frequency Range	Test Limits (sec)
1.0 E3	MIN	5.0E-3 ± 1.0E-6
2.0 E3	MAX	2.5E-4 ± 3.0E-5
2.5 E5	MIN	2.0E-7 ± 3.4E-9
5.0 E5	MAX	1.0E-7 ± 1.5E-8

Example Program

This program performs the Duty Cycle Test.

```
10!   RE-STORE "DUTY_CYCLE"
20    DIM Freq(1:4),Range$(1:4)[10]
30    !
40    !---------- Set up I/O path and reset AFG ----------
50    ASSIGN @Afg TO 70910
60    OUTPUT @Afg;"*RST;*CLS"                          !Reset AFG
70    !
80    !---------- Initialize variables ----------
90    DATA 1E3,2E3,2.5E5,5E5
100   READ Freq(*)
110   !
120   DATA MIN,MAX,MIN,MAX                             !'MAX' enables doubling
130   READ Range$(*)                                   !'MIN' disables doubling
140   !
150   !---------- Set up Counter ----------
160   CLEAR SCREEN
170   PRINT "Set up Counter:"
180   PRINT "     Function -- Pulse Width"
190   PRINT "     Coupling -- DC"
210   PRINT "     Input Impedance -- 50 ohms"
220   PRINT
230   PRINT "Connect Counter to AFG Output."
240   DISP "Press 'Continue' when ready"
250   PAUSE
260   CLEAR SCREEN
270   !
280   !---------- Set up AFG ----------
290   OUTPUT @Afg;"*RST"                               !Reset AFG
300   OUTPUT @Afg;"FUNC SQU;";                         !Squarewave
310   OUTPUT @Afg;":VOLT MAX"                          !MAX output
320   !
330   !---------- Perform test ----------
340   FOR I=1 TO 4
350      OUTPUT @Afg;"ABORT"                           !Abort waveform
360      OUTPUT @Afg;"FREQ:RANG "&Range$(I)&";";       !Freq doubling on/off
370      OUTPUT @Afg;":FREQ "&VAL$(Freq(I))            !Set frequency
380      OUTPUT @Afg;"INIT:IMM"                        !Initiate
390      WAIT 1
400      !
```

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Test 2-8: Duty Cycle (cont'd)

Example Program (cont'd)

```
410       !Take readings here
420       PRINT "Output Frequency =";Freq(I);" Hz"
430       PRINT
440       PRINT "Read positive pulse width (average at least 10 periods)."
450       INPUT "Enter positive pulse width (in sec):",Pos_width
460       !
470       PRINT "Set Counter to measure period (average at least 10 periods)."
480       INPUT "Enter period (in sec):",Period
490       !
500       !Calculate duty cycle
510       Duty_cycle=(Pos_width/(Period))*100
520       Duty_cycle=PROUND(Duty_cycle,-2)
530       PRINT
540       PRINT "Positive Pulse Width = "&VAL$(Pos_width)
550       PRINT "Duty Cycle = "&VAL$(Duty_cycle)&"%"
560       !
570       DISP "Press 'Continue' when ready"
580       PAUSE
590       CLEAR SCREEN
600     NEXT I
610     !
620     OUTPUT @Afg;"*RST;*CLS"                         !Reset AFG
630     END
```

Test 2-9: Total Harmonic Distortion

Description

The purpose of this test is to verify that the AFG meets its specifications for sine wave total harmonic distortion (THD).

Equipment Setup

- Connect equipment as shown in Figure 2-10
- Set Spectrum Analyzer to:

Ref Level = 25 dBm
Freq Span = 1 kHz
Resolution BW = 30 Hz
Video BW = 30 Hz

NOTE *These are recommended settings only. Adjust your Spectrum Analyzer as necessary.*

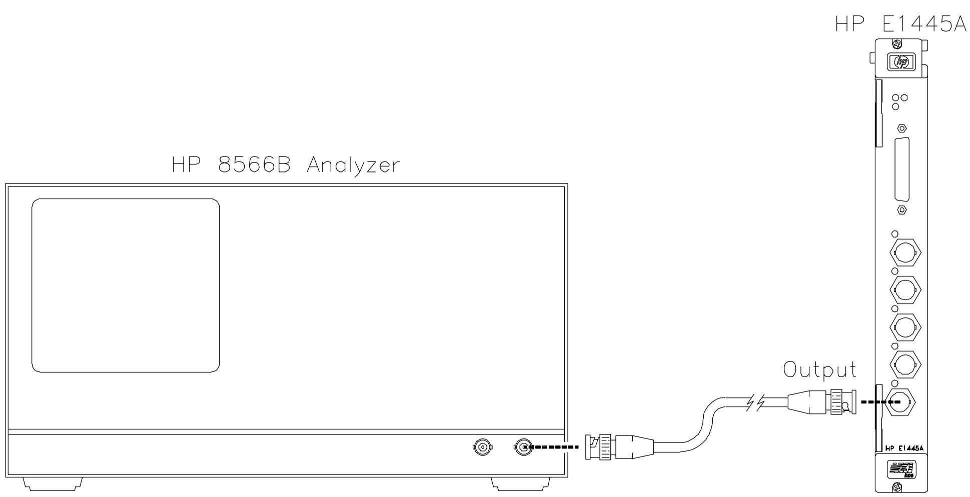

Figure 2-10. Equipment Setup for Test 2-9 and Test 2-10

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set the AFG to output a sinewave with the 10 MHz filter enabled:

VOLT 24DBM	*Set AFG amplitude*
OUTP:FILT:FREQ 10 MHZ	*Set filter to 10 MHz*
OUTP:FILT ON	*Enable filter*
INIT:IMM	*Initiate waveform*

Perform steps 3 - 6 for each frequency listed in Table 2-9:

3. Set AFG output frequency:

FREQ *<frequency>*	*Set frequency*

   where *<frequency>* is the value specified in Table 2-9.

4. Set the Spectrum Analyzer center frequency to the output frequency of the AFG. Measure the peak amplitude of the fundamental in dBm. Note the result for use in step 6.

5. Set the Spectrum Analyzer center frequency to the second harmonic ($2 \times \textit{fundamental frequency}$). Measure the peak amplitude of the second harmonic in dBm.

6. Repeat step 5 for third through ninth harmonics. Calculate total harmonic distortion as shown below:

$$\text{thd (dBc)} = 20 \cdot \log\left(\sqrt{\text{result}_2{}^2 + \text{result}_3{}^2 + \ldots + \text{result}_9{}^2}\right)$$

   where

$$\text{result}_n \text{ (volts)} = 10^{[(n^{th}\text{ Harmonic (dBm)} - \text{Fundamental (dBm)})/20]}$$

Test 2-9: Total Harmonic Distortion (cont'd)

Test Procedure (cont'd)

Table 2-9. THD Test Points

Frequency (Hz)	Test Limits* (dBc)
100 E3	-60
250 E3	-60
1 E6	-48
4 E6	-36
10 E6	-36

* Through 9th harmonic

Example Program

This program performs the Total Harmonic Distortion Test.

```
10 !   RE-STORE "SINE_THD"
20     DIM Freq(1:5)
30     !
40     !---------- Set up I/O path and reset AFG ----------
50     ASSIGN @Afg TO 70910                              !AFG I/O path
60     OUTPUT @Afg;"*RST;*CLS"                           !Reset AFG
70     !
80     !---------- Initialize variables ----------
90     Dbm_out$="24DBM"                                  !AFG output
100    !
110    DATA 100E3,250E3,1E6,4E6,10E6                     !Read in freqs
120    READ Freq(*)
130    !
140    !---------- Set up Spec Analyzer ----------
150    CLEAR SCREEN
160    PRINT "Set up Spectrum Analyzer:"
170    PRINT
180    PRINT "     Ref Level = 25 dBm"
190    PRINT "     Span = 1 kHz"
200    PRINT "     Resolution BW = 30 Hz"
210    PRINT "     Video BW = 30 Hz"
220    PRINT
```

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Test 2-9: Total Harmonic Distortion (cont’d)

Example Program (cont’d)

```
230  PRINT "Connect Spectrum Analyzer to AFG Output."
240  DISP "Press ’Continue’ when ready"
250  PAUSE
260  !
270  !---------- Set up AFG ----------
280  OUTPUT @Afg;"*RST"                            !Reset AFG
290  WAIT 1
300  OUTPUT @Afg;"VOLT "&Dbm_out$                  !Set AFG output
310  OUTPUT @Afg;"OUTP:FILT:FREQ 10MHZ"            !Enable 10MHz filter
320  OUTPUT @Afg;"OUTP:FILT ON"
330  OUTPUT @Afg;"INIT:IMM"                        !Initiate
340  !
350  !---------- Perform test ----------
360  FOR I=1 TO 5
370    OUTPUT @Afg;"FREQ "&VAL$(Freq(I))           !Set frequency
380    !
390    CALL Meas_thd(Freq(I),Thd)                  !Measure THD
400    PRINT "Fundamental Frequency =";Freq(I)
410    PRINT "THD =";DROUND(Thd,4);"dBc"
420    PRINT
430    DISP "Press ’Continue’ when ready"
440    PAUSE
450    DISP
460  NEXT I
470  !
480  OUTPUT @Afg;"*RST;*CLS"                       !Reset AFG
490  END
500  !
510  !
520  !---------- Measurement subprogram ----------
530  SUB Meas_thd(Frequency,Thd)
540    INTEGER Harmonic
550    CLEAR SCREEN
560    Harmonic=1
570    !
580    GOSUB Meas_fund                             !Get fundamental amplitude
590    !
```

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Example Program (cont'd)

```
600      !Measure harmonics 2-9
610      Sum_amp_sqr=0
620      FOR Harmonic=2 TO 9
630         GOSUB Meas_amp
640         Sum_amp_sqr=Sum_amp_sqr+10^(Result/10)       !Sum of squared voltages
650      NEXT Harmonic
660      !
670      Thd=20*LGT(SQRT(Sum_amp_sqr))                   !Calculate THD In dBc
680      SUBEXIT
690      !
700 Meas_fund:  !
710      PRINT "FUNDAMENTAL"
720      PRINT "Set Spectrum Analyzer Center Freq to: "&VAL$(Frequency)&" Hz."
730      PRINT "Measure amplitude at the center frequency."
740      PRINT
750      INPUT "Enter amplitude (in dBm):",Baseline
760      RETURN
770      !
780 Meas_amp:  !
790      PRINT "HARMONIC =";Harmonic
800      PRINT "Set Spectrum Analyzer Center Freq to: "&VAL$(Frequency*Harmonic)&" Hz."
810      PRINT "Measure amplitude at the center frequency."
820      PRINT
830      INPUT "Enter amplitude (in dBm):",Reading
840      Result=Reading-Baseline
850      RETURN
860   SUBEND
```

Test 2-10: Spurious/Non-Harmonic Distortion

Description

The purpose of this test is to verify that the AFG meets its specifications for non-harmonic and spurious distortion.

Equipment Setup

- Connect equipment as shown in Figure 2-9
- Set Spectrum Analyzer to :

  Ref Level = -5 dBm
  Resolution BW = 3 kHz
  Video BW = 3 kHz

NOTE

These are recommended settings only. Adjust your Spectrum Analyzer as necessary.

Test Procedure

1. Reset the AFG:

*RST;*CLS	*Reset AFG and clear status registers*

2. Set the AFG to output a -5 dBm, 10 MHz sinewave with the 10 MHz filter enabled:

FREQ 1.0E7;	*Set AFG frequency*
:VOLT -5DBM	*Set AFG amplitude*
OUTP:FILT:FREQ 10 MHZ	*Set filter to 10 MHz*
OUTP:FILT ON	*Enable filter*
INIT:IMM	*Initiate waveform*

Test Procedure (cont'd)

Perform steps 3 and 4 for each frequency range listed in Table 2-10:

3. Set the Spectrum Analyzer start frequency and stop frequency to the values listed in Table 2-10.

4. Measure the amplitude (in dBm) of the highest peak. Subtract the amplitude of the fundamental (-5dBm) from the reading and record the result in Table 2-11:

   result (dBc) = reading (dBm) – (–5 dBm)

Table 2-10. Spurious/Non-Harmonic Test Points

Start Frequency (Hz)	Stop Frequency (Hz)	Test Limits (dBc)
100 E3	9.5 E6	-45
10.5 E6	19 E6	-45
21 E6	29 E6	-45
31 E6	39 E6	-45
41 E6	49 E6	-45
51 E6	75 E6	-45
75 E6	100 E6	-45
100 E6	125 E6	-45
125 E6	150 E6	-45

Test 2-10: Spurious/Non-Harmonic Distortion (cont'd)

Example Program

This program performs the Spurious/Non-harmonic Test.

```
10 !  RE-STORE "NON_HARM"
20    DIM Start_freq(1:9),Stop_freq(1:9),Max_ampl(1:9)
30    !
40    !---------- Set up I/O path and reset AFG ----------
50    ASSIGN @Afg TO 70910                           !AFG I/O path
60    OUTPUT @Afg;"*RST;*CLS"                        !Reset AFG
70    !
80    !---------- Initialize variables ----------
90    Freq_out=1.0E+7                                !Freq = 10 MHz
100   Dbm_out$="-5DBM"                               !Amplitude = -5dBm
110   !
120   DATA 100E3,10.5E6,21E6,31E6,41E6,51E6,75E6,100E6,125E6
130   READ Start_freq(*)                             !Read start freqs
140   !
150   DATA 9.5E6,19E6,29E6,39E6,49E6,75E6,100E6,125E6,150E6
160   READ Stop_freq(*)                              !Read stop freqs
170   !
180   !---------- Set up Spec Analyzer ----------
190   CLEAR SCREEN
200   PRINT "Set up Spectrum Analyzer:"
210   PRINT
220   PRINT "     Ref Level = -5dBm"
230   PRINT "     Resolution BW = 3 kHz"
240   PRINT "     Video BW = 3 kHz"
250   PRINT
260   PRINT "Connect Spectrum Analyzer to AFG Output."
270   DISP "Press 'Continue' when ready"
280   PAUSE
290   CLEAR SCREEN
300   !
310   !---------- Set up AFG ----------
320   OUTPUT @Afg;"*RST"                             !Reset AFG
330   WAIT 1
340   OUTPUT @Afg;"FREQ "&VAL$(Freq_out)&";";        !Set frequency
350   OUTPUT @Afg;":VOLT "&Dbm_out$                  !Set amplitude
360   OUTPUT @Afg;"OUTP:FILT:FREQ 10MHZ"             !Enable 10MHz filter
370   OUTPUT @Afg;"OUTP:FILT ON"
380   OUTPUT @Afg;"INIT:IMM"                         !Initiate
390   !
```

(Continued on next page)

Example Program (cont'd)

```
400   !---------- Perform test ----------
410   FOR I=1 TO 9
420      CLEAR SCREEN
430      PRINT "Set Spectrum Analyzer Start Freq to: ";Start_freq(I);"Hz"
440      PRINT "Set Spectrum Analyzer Stop Freq to: ";Stop_freq(I);"Hz"
450      PRINT "Measure the amplitude of the highest peak."
460      PRINT
470      INPUT "Enter amplitude (in dBm):",Peak_ampl
480      PRINT "Result =";VAL(Dbm_out$)-Peak_ampl;"dBc"    !Calculate result in dBc
490      DISP "Press 'Continue' when ready"
500      PAUSE
510      DISP
520   NEXT I
530   !
540   OUTPUT @Afg;"*RST;*CLS"                           !Reset AFG
550   END
```

Performance Test Record

Table 2-11, *Performance Test Record for the Agilent E1445A AFG*, is a form you can copy and use to record performance verification test results for the AFG. Table 2-11 shows AFG accuracy, measurement uncertainty, and test accuracy ratio (TAR) values.

AFG Test Limits

Test limits are defined using the specifications in Appendix A of the *Agilent E1445A User's Manual*. The specifications for Total Harmonic Distortion and Spurious/Non-harmonic Distortion are single-sided (i.e., there is an upper limit but no lower limit). In the Performance Test Record, the Minimum column will be blank.

Measurement Uncertainty

For the performance verification tests in this manual, the measurement uncertainties are based on the accuracy specifications for the following test equipment:

Performance Test	Test Equipment
1. DC Zeros	Agilent 3458A
2. DC Accuracy	Agilent 3458A
3. DC Offset	Agilent 3458A
4. AC Accuracy	Agilent 3458A
5. AC Flatness (250 kHz filter)	Agilent 3458A
6. AC Flatness (10 MHz filter)*	Agilent 3458A Agilent 8902A
7. Frequency Accuracy	Agilent 5334B
8. Duty Cycle	Agilent 5334B
9. Total Harmonic Distortion	Agilent 8566B
10. Spurious/Non-harmonic Distortion	Agilent 8566B

* Includes following uncertainties: 8902A Range linearity, 11722A Power Sensor Cal Factor uncertainty, 3458A accuracy at 100 kHz.

Test Accuracy Ratio (TAR)

Test Accuracy Ratio (TAR) for the E1445A is defined as: AFG Accuracy/Measurement Uncertainty, i.e.,

$$\text{TAR} = \frac{\text{Maximum} - \text{Expected Reading}}{\text{Measurement Uncertainty}}$$

For single-sided measurements, Test Accuracy Ratio is not defined, so 'NA' (Not Applicable) will appear in the TAR column. For TARs that exceed 10:1, the entry is '>10:1'.

Table 2-11. Performance Test Record for the Agilent E1445A (Page 1 of 7)

Test Facility:

Name ______________________________________ Report No. ___________________________________

Address ______________________________________ Date ____

City/State ___________________________________ Customer ___________________________________

Phone _______________________________________ Tested by ____________________________________

Model _____________________________________ Ambient temperature _______________________ °C

Serial No. __________________________________ Relative humidity _____________________________%

Options ____________________________________ Line frequency ______________________ Hz (nominal)

Firmware Rev. _______________________________

Special Notes:

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Table 2-11. Performance Test Record for the Agilent E1445A (Page 2 of 7)

Model ____________________________	**Report No.** ___________________________	**Date** _______________

Test Equipment Used: Description	**Model No.**	**Trace No.**	**Cal Due Date**
1. ______________________________	______________	______________	______________
2. ______________________________	______________	______________	______________
3. ______________________________	______________	______________	______________
4. ______________________________	______________	______________	______________
5. ______________________________	______________	______________	______________
6. ______________________________	_______________	______________	______________
7. ______________________________	______________	______________	______________
8. ______________________________	_______________	______________	______________
9. ______________________________	______________	______________	______________
10. _____________________________	______________	______________	______________
11. _____________________________	______________	______________	______________
12. _____________________________	______________	______________	______________
13. _____________________________	______________	______________	______________
14. ____________________________	______________	______________	______________
15. ____________________________	______________	______________	______________
16. ____________________________	______________	______________	______________
17. ____________________________	______________	______________	______________
18. ____________________________	______________	______________	______________
19. ____________________________	______________	______________	______________
20. ____________________________	______________	______________	______________

Table 2-11. Performance Test Record for the Agilent E1445A (Page 3 of 7)

Model ____________________________	**Report No.** ___________________________	**Date** ______________

Test Description*	Minimum	Measured Reading	Maximum	Meas Uncert	TAR
Test 2-1. DC Zeros Test (Values in Vdc)					
No Filter:					
10.2375V (0 dB atten)	-0.022	____________	0.022	1E-6	>10:1
9.1347V (.99 dB atten)	-0.022	____________	0.022	1E-6	>10:1
9.1241V (1 dB atten)	-0.022	____________	0.022	1E-6	>10:1
8.1319V (2 dB atten)	-0.022	____________	0.022	1E-6	>10:1
6.4594V (4 dB atten)	-0.022	____________	0.022	1E-6	>10:1
4.0756V (8 dB atten)	-0.022	____________	0.022	1E-6	>10:1
2.2918V (13 dB atten)	-0.022	____________	0.022	1E-6	>10:1
2.0426V (14 dB atten)	-0.0044	____________	0.0044	1E-6	>10:1
0.3238V (30 dB atten)	-0.0044	____________	0.0044	1E-6	>10:1
250 kHz Filter:					
10.2375V (0 dB atten)	-0.022	____________	0.022	1E-6	>10:1
9.1347V (.99 dB atten)	-0.022	____________	0.022	1E-6	>10:1
9.1241V (1 dB atten)	-0.022	____________	0.022	1E-6	>10:1
8.1319V (2 dB atten)	-0.022	____________	0.022	1E-6	>10:1
6.4594V (4 dB atten)	-0.022	____________	0.022	1E-6	>10:1
4.0756V (8 dB atten)	-0.022	____________	0.022	1E-6	>10:1
2.2918V (13 dB atten)	-0.022	____________	0.022	1E-6	>10:1
2.0426V (14 dB atten)	-0.0044	____________	0.0044	1E-6	>10:1
0.3238V (30 dB atten)	-0.0044	____________	0.0044	1E-6	>10:1
10 MHz Filter:					
10.2375V (0 dB atten)	-0.022	____________	0.022	1E-6	>10:1
9.1347V (.99 dB atten)	-0.022	____________	0.022	1E-6	>10:1
9.1241V (1 dB atten)	-0.022	____________	0.022	1E-6	>10:1
8.1319V (2 dB atten)	-0.022	____________	0.022	1E-6	>10:1
6.4594V (4 dB atten)	-0.022	____________	0.022	1E-6	>10:1
4.0756V (8 dB atten)	-0.022	____________	0.022	1E-6	>10:1
2.2918V (13 dB atten)	-0.022	____________	0.022	1E-6	>10:1
2.0426V (14 dB atten)	-0.0044	____________	0.0044	1E-6	>10:1
0.3238V (30 dB atten)	-0.0044	____________	0.0044	1E-6	>10:1

* Since the arbitrary waveform consists of zeros, the expected reading is 0 V, regardless of the amplitude setting. The amplitude is changed in order to turn the various attenuators on and off.

Table 2-11. Performance Test Record for the Agilent E1445A (Page 4 of 7)

Model ______________________ **Report No.** ______________________ **Date** ______________

Test Description	Minimum	Measured Reading	Maximum	Meas Uncert	TAR
Test 2-2. DC Accuracy Test (Values in Vdc)					
No Filter:					
10.2375V	10.1863	________	10.2887	4.9E-5	>10:1
5.0V	4.9645	________	5.0355	2.5E-5	>10:1
0.0V	-0.0205	________	0.0205	1.0E-6	>10:1
-5.0V	-5.0355	________	-4.9645	2.5E-5	>10:1
-10.24V	-10.2912	________	-10.1888	4.9E-5	>10:1
250 kHz Filter:					
10.2375V	10.1863	________	10.2887	4.4E-5	>10:1
-10.24V	-10.2912	________	-10.1888	2.3E-5	>10:1
10 MHz Filter:					
10.2375V	10.1863	________	10.2887	4.4E-5	>10:1
-10.24V	-10.2912	________	-10.1888	2.3E-5	>10:1
Test 2-3. DC Offset Test (Values in Vdc)					
13 dB attenuation:					
9.755V	9.6355	________	9.8746	4.7E-5	>10:1
4.0V	3.9380	________	4.0620	2.04E-5	>10:1
-4.0V	-4.0620	________	-3.9380	2.04E-5	>10:1
-9.755V	-9.8746	________	-9.6355	4.7E-5	>10:1
28 dB attenuation:					
2.0V	1.9756	________	2.0244	1.12E-5	>10:1
-2.0V	-2.0244	________	-1.9756	1.12E-5	>10:1
Test 2-4. AC Accuracy Test (Values in Vac)					
No Filter:					
7.239V (0 dB atten)	7.1561	________	7.3228	2.46E-3	>10:1
6.45V (1 dB atten)	6.3396	________	6.5624	2.3E-3	>10:1
5.75V (2 dB atten)	5.6516	________	5.8502	2.16E-3	>10:1
4.566V (4 dB atten)	4.4878	________	4.6455	1.9E-3	>10:1
2.881V (8 dB atten)	2.8317	________	2.9312	1.58E-3	>10:1
1.440V (14 dB atten)	1.4153	________	1.4651	1.29E-3	>10:1
0.229V (30 dB atten)	0.2251	________	0.2330	1.46E-4	>10:1
250 kHz Filter:					
7.239V (0 dB atten)	7.1561	________	7.3228	2.46E-3	>10:1

10 MHz Filter:					
7.239V (0 dB atten)	7.1561	____________	7.3228	2.46E-3	>10:1

Table 2-11. Performance Test Record for the Agilent E1445A (Page 5 of 7)

Model ____________________________ **Report No.** ___________________________ **Date** _______________

Test Description	Minimum	Measured Reading	Maximum	Meas Uncert	TAR
Test 2-5. AC FlatnessTest - 250 kHz Filter (Values in dB error, relative to 1 kHz))					
Amplitude at 24 dBm:					
10 kHz	-0.05	____________	0.05	.002 dB	>10:1
20 kHz	-0.05	____________	0.05	.002 dB	>10:1
30 kHz	-0.05	____________	0.05	.0034 dB	>10:1
40 kHz	-0.05	____________	0.05	.0034 dB	>10:1
50 kHz	-0.05	____________	0.05	.0034 dB	>10:1
60 kHz	-0.05	____________	0.05	.0077 dB	7:1
70 kHz	-0.05	____________	0.05	.0077 dB	7:1
80 kHz	-0.05	____________	0.05	.0077 dB	7:1
90 kHz	-0.05	____________	0.05	.0077 dB	7:1
100 kHz	-0.05	____________	0.05	.0077 dB	7:1
110 kHz	-0.10	____________	0.10	.028 dB	4:1
120 kHz	-0.10	____________	0.10	.028 dB	4:1
130 kHz	-0.10	____________	0.10	.028 dB	4:1
140 kHz	-0.10	____________	0.10	.028 dB	4:1
150 kHz	-0.10	____________	0.10	.028 dB	4:1
160 kHz	-0.10	____________	0.10	.028 dB	4:1
170 kHz	-0.10	____________	0.10	.028 dB	4:1
180 kHz	-0.10	____________	0.10	.028 dB	4:1
190 kHz	-0.10	____________	0.10	.028 dB	4:1
200 kHz	-0.10	____________	0.10	.028 dB	4:1
210 kHz	-0.10	____________	0.10	.028 dB	4:1
220 kHz	-0.10	____________	0.10	.028 dB	4:1
230 kHz	-0.10	____________	0.10	.028 dB	4:1
240 kHz	-0.10	____________	0.10	.028 dB	4:1
250 kHz	-0.10	____________	0.10	.028 dB	4:1

Table 2-11. Performance Test Record for the Agilent E1445A (Page 6 of 7)

Model ______________________________	**Report No.** _____________________________	**Date** _______________

Test Description	Minimum	Measured Reading	Maximum	Meas Uncert	TAR
Test 2-6. AC FlatnessTest - 10 MHz Filter (Values in dB error, relative to 1 kHz)					
Amplitude at 24 dBm:					
400 kHz	-0.2	____________	0.2	0.0478 dB	4:1
800 kHz	-0.2	____________	0.2	0.0506 dB	4:1
1.2 MHz	-0.2	____________	0.2	0.0506 dB	4:1
1.6 MHz	-0.2	____________	0.2	0.0506 dB	4:1
2.0 MHz	-0.2	____________	0.2	0.0506 dB	4:1
2.4 MHz	-0.2	____________	0.2	0.0506 dB	4:1
2.8 MHz	-0.2	____________	0.2	0.0506 dB	4:1
3.2 MHz	-0.2	____________	0.2	0.0506 dB	4:1
3.6 MHz	-0.2	____________	0.2	0.0506 dB	4:1
4.0 MHz	-0.2	____________	0.2	0.0506 dB	4:1
4.4 MHz	-0.2	____________	0.2	0.0506 dB	4:1
4.8 MHz	-0.2	____________	0.2	0.0506 dB	4:1
5.2 MHz	-0.2	____________	0.2	0.0506 dB	4:1
5.6 MHz	-0.2	____________	0.2	0.0506 dB	4:1
6.0 MHz	-0.2	____________	0.2	0.0506 dB	4:1
6.4 MHz	-0.2	____________	0.2	0.0506 dB	4:1
6.8 MHz	-0.2	____________	0.2	0.0536 dB	4:1
7.2 MHz	-0.2	____________	0.2	0.0536 dB	4:1
7.6 MHz	-0.2	____________	0.2	0.0536 dB	4:1
8.0 MHz	-0.2	____________	0.2	0.0536 dB	4:1
8.4 MHz	-0.2	____________	0.2	0.0536 dB	4:1
8.8 MHz	-0.2	____________	0.2	0.0536 dB	4:1
9.2 MHz	-0.2	____________	0.2	0.0536 dB	4:1
9.6 MHz	-0.2	____________	0.2	0.0536 dB	4:1
10.0 MHz	-0.2	____________	0.2	0.0536 dB	4:1
10.4 MHz	-0.2	____________	0.2	0.0536 dB	4:1
10.8 MHz	-0.2	____________	0.2	0.0536 dB	4:1

Table 2-11. Performance Test Record for the Agilent E1445A (Page 7 of 7)

Model ______________________________	**Report No.** _____________________________	**Date** _______________

Test Description	Minimum	Measured Reading	Maximum	Meas Uncert	TAR
Test 2-7. Frequency Accuracy Test (Values in Hz) *					
Marker source is "ROSC":					
42.9497 MHz	42.9467E6	____________	42.9527E6	8.0	>10:1
40.0 MHz	39.9972E6	____________	40.0028E6	8.0	>10:1
Marker source is "TRIG":					
20.0 MHz	19.9986E6	____________	20.0014E6	5.0	>10:1
13.3333 MHz	13.3324E6	____________	13.3342E6	3.8	>10:1
305.176 Hz	305.1546	____________	305.1974	0.00305	7:1
Test 2-8. Duty Cycle Test (Values in nsec)					
1 kHz, .5 msec pulse width	4.99E-4	____________	5.01E-4	2.1E-9	>10:1
2 kHz, .25 msec pulse width	2.2E-4	____________	2.8E-4	1.8E-9	>10:1
250 kHz, 2 µsec pulse width	1.993E-6	____________	2.007E-6	1.2E-9	6:1
500 kHz, 1 µsec pulse width	8.77E-7	____________	1.123E-6	1.2E-9	>10:1
Test 2-9. Total Harmonic Distortion Test (Values in dBc) **					
24 dBm sinewave:					
100 kHz		____________	-60 dBc	1.23 dB	NA
250 kHz		____________	-60 dBc	1.23 dB	NA
1 MHz		____________	-48 dBc	1.23 dB	NA
4 MHz		____________	-36 dBc	1.23 dB	NA
10 MHz		____________	-36 dBc	1.23 dB	NA
Test 2-10. Spurious/Non-harmonic Distortion Test (Values in dBc) **					
10 MHz, -5 dBm sinewave:					
100 kHz - 9.5 MHz		____________	-45 dBc	1.23 dB	NA
10.5 MHz - 19 MHz		____________	-45 dBc	1.23 dB	NA
21 MHz - 29 MHz		____________	-45 dBc	1.23 dB	NA
31 MHz - 39 MHz		____________	-45 dBc	1.23 dB	NA
41 MHz - 49 MHz		____________	-45 dBc	1.23 dB	NA
51 MHz - 75 MHz		____________	-45 dBc	1.23 dB	NA
75 MHz - 100 MHz		____________	-45 dBc	1.23 dB	NA
100 MHz - 125 MHz		____________	-45 dBc	1.23 dB	NA
125 MHz - 150 MHz		____________	-45 dBc	1.23 dB	NA

* Test limits assume 1 year of aging @ ±20 ppm/year
** Single-sided test -- Minimum is not applicable

Chapter 3
Adjustments

Introduction

The procedures in this chapter show how to perform the following electronic adjustments for the AFG:

- DC Accuracy
- AC Flatness (250 kHz and 10MHz filters)
- Skew

NOTE

The DC adjustment procedure should be performed before the AC flatness adjustment procedures.

Required Equipment

See Table 1-1 for test equipment required for the procedures described in this chapter.

Recommended Environment

Before performing these procedures, allow the AFG to warm up for at least one hour. The temperature should be within ±5^{o}C of T_{cal} (the temperature of the most recent calibration), and between 18^{o}C and 28^{o}C.

Calibration Commands

This section provides a brief description of commands that relate to calibration of the AFG. More information on these commands can be found in the Command Reference section of the *Agilent E1445A User's Manual.*

- **CALibration:COUNt?** returns the number of times that the AFG has been calibrated. Each adjustment procedure in this chapter increments the calibration number by 1.

- **CALibration:SECure:CODE <code>** sets the code that disables calibration security. The code is set at the factory to "E1445A". Calibration security must be disabled before changing the code.

Calibration Commands (cont'd)

- **CALibration:SECure[:STATe] <mode>[,<code>]** enables (**<mode>** = ON) or disables (**<mode>** = OFF) calibration security. The security code is required for CAL:SEC:STAT OFF, but the code is optional for CAL:SEC:STAT ON. The *RST command also enables calibration security.

- **CALibration[:DC]:BEGin** starts the DC calibration sequence and sets up the AFG for the first calibration point.

- **CALibration[:DC]:POINt? <value>** sends a value to the AFG so that the appropriate calibration constant(s) can be calculated. The AFG returns two numbers: (1) the current calibration point, and (2) an error code (see Appendix B of the *Agilent E1445A User's Manual* for more information about AFG errors). Any non-zero error code indicates a failure. This command also sets up the AFG for the next calibration point.

- **CALibration:DATA[:DC] <block>** transfers the DC calibration constants to the AFG. The DC calibration procedure described in this chapter should be used in place of this command. The query form returns the current DC constants in IEEE-488.2 definite block data format.

- **CALibration:DATA:AC[1] <block>** transfers the AC calibration constants that are used with the 250 kHz filter. The query form returns the current constants in IEEE-488.2 definite block data format. See the AC Flatness Adjustment procedures for more information on the use of this command.

- **CALibration:DATA:AC2 <block>** transfers the AC calibration constants that are used with the 10 MHz filter. The query form returns the current constants in IEEE-488.2 definite block data format. See the AC Flatness Adjustment procedures for more information on the use of this command.

Calibration Commands (cont'd)

- **CALibration:DATA:FILTer <block>** transfers the two calibration constants that are used to determine the frequency points that will be calibrated for the 10 MHz filter. The query form returns the current constants in IEEE-488.2 definite block data format. See the AC Flatness Adjustment procedure for the 10 MHz filter for more information on the use of this command.

- **CALibration:DATA:SKEW <data>** transfers the calibration constant that is used by the skew DAC to synchronize the AFG's DAC's. The query form returns the current constant in IEEE-488.2 definite block data format. See the Skew DAC Adjustment procedure for more information on the use of this command.

NOTE

*The CAL:DATA:FILT and CAL:DATA:SKEW commands are available only on units with firmware rev A.02.00 or higher (use the *IDN? command to determine the AFG's firmware revision).*

- **CALibration:STATe:AC <state>** enables or disables AC corrections using the calibration constants. If **<state>** is ON, corrections will be used. If **<state>** is OFF, corrections will not be used.

- **CALibration:STATe:DC <state>** enables or disables DC corrections using the calibration constants. If **<state>** is ON, corrections will be used. If **<state>** is OFF, corrections will not be used.

- **CALibration:STATe <state>** enables or disables both AC and DC corrections using the calibration constants. If **<state>** is ON, corrections will be used. If **<state>** is OFF, corrections will not be used.

- ***PUD <data>**stores the specified data in non-volatile "protected user data" memory. The data must be sent in IEEE-488.2 definite or indefinite block format. The query form (***PUD?**) returns the current protected user data in IEEE-488.2 definite block format.

Defeating Calibration Security

If the calibration security code is unknown, the security feature can be defeated by disassembling the AFG and moving the jumper on connector J104 (see Figure 3-1) to the unsecured position (left-most pins). To prevent accidental or unauthorized calibration, move the jumper back to the secured position (right-most pins) as soon as the security code has been set to the desired value (use the CALibration:SECure:CODE <code> command). Disassembly instructions can be found in Chapter 5.

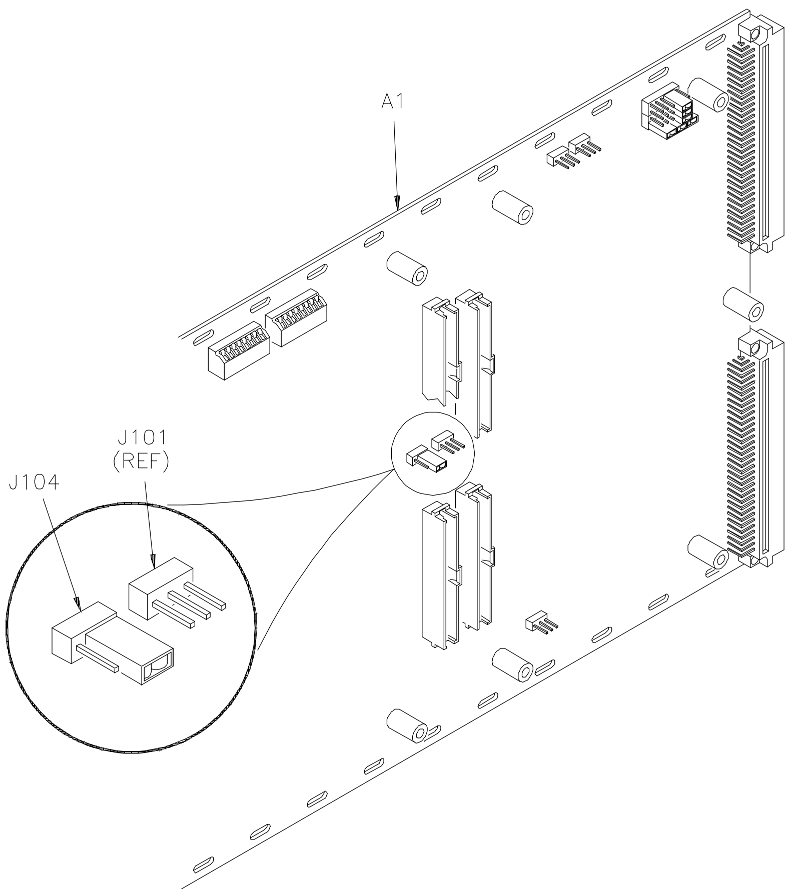

Figure 3-1. Disabling Calibration Security (shown in secured position)

DC Adjustment Procedure

Description

A DC adjustment is performed on the AFG by reading a series of voltages and resistances output by the AFG, then entering those values back into the AFG. After all measurements have been completed, new calibration constants are calculated and stored in non-volatile memory. To ensure accuracy, perform the DC calibration procedure at one year intervals.

This procedure uses a firmware routine to adjust the AFG's DC calibration constants. The CALibration[:DC]:BEGin command starts the DC calibration sequence and the CALibration[:DC]:POINt? command steps the AFG to the next calibration point. All AFG settings are performed by the firmware routine.

NOTE *If an error occurs at any time during the procedure, abort (*RST) and start over.*

Equipment Setup

- Perform a complete autocalibration on the DMM (unless an autocal has been performed within the last 24 hours)
- Connect the equipment as shown in Figure 3-2

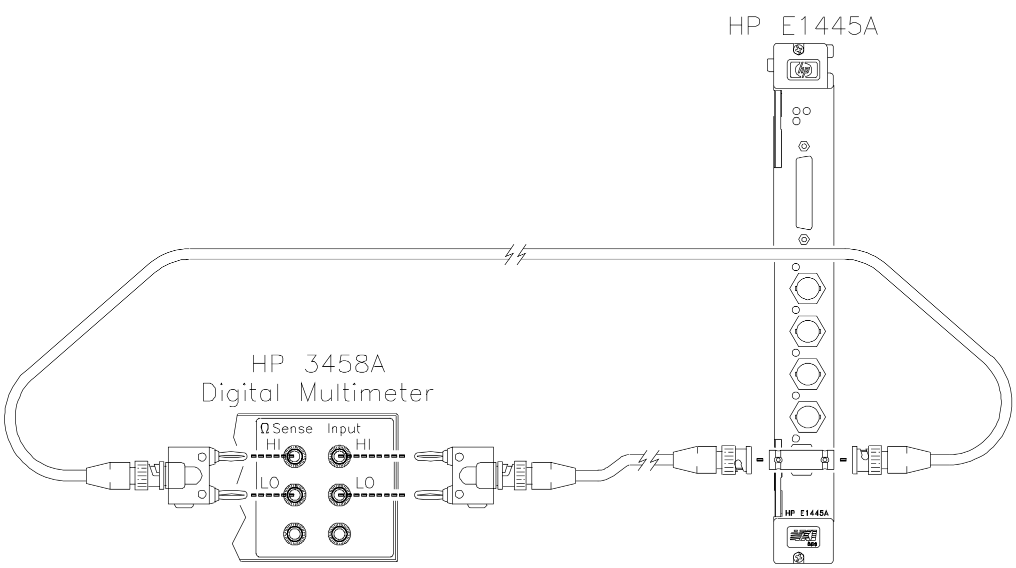

Figure 3-2. DC Adjustment Setup

Adjustment Procedure

1. Reset the AFG:

   *RST;*CLS — *Reset AFG and clear status registers*

2. Enable calibration on the AFG:

   CAL:SEC:STAT OFF, <security code> — *Cal security off*

   where <code> is the AFG's security code (factory-set to "E1445A").

3. Send the command to start the DC adjustment routine and wait for the command to complete:

   CAL:DC:BEGIN
   *OPC?

   The AFG will return a "1" when ready.

Repeat steps 4 through 6 for calibration points 1 - 44:

4. If the current calibration point is listed in Table 3-2, set up the DMM as specified. Otherwise, do not change the DMM settings. Note the special instructions for the following points:

   Cal Point 31. Immediately after performing the DMM measurement for cal point 30 (and before sending the reading to the AFG) set the DMM range to 10 V. This will prevent an overload when the AFG sets itself for the next reading.

   Cal Point 41. Immediately before setting up the DMM for cal point 41, take a reading using the DMM settings for cal point 40. This will provide a DC offset reading. Next, set up the DMM for cal point 41 as specified in Table 3-2. Then use the DC offset reading and Table 3-1 to determine the appropriate DMM range for subsequent calibration points.

   Cal Point 43. Same instructions as cal point 41.

Test Procedure (cont'd)

5. Trigger the DMM and note the reading.

6. Send the reading to the AFG:

   CAL:DC:POINT? <*reading*>

   where <*reading*> is the DMM reading from step 5. The AFG will return, in order, the number of the current cal point and an error code. Any non-zero error code indicates a failure.

Table 3-1. DMM Range Setting for Cal Points 41 and 43

Absolute Value of DC Offset	DMM Range
Less than 10 mV	100 Ω
Between 10 mV and 100 mV	1000 Ω
Greater than 100 mV	Offset too high - abort cal

Table 3-2. DC Calibration Points

Cal Point	DMM Settings (changes only)
1	DCV, 10 V range, 10 NPLC
29	1 V range, 20 NPLC
31	10 V*
33	100 mV range
41	4-wire ohms, offset comp on*
43	4-wire ohms, offset comp on*

*See Step 4 of the "DC Adjustment Procedure" for special instructions.

DC Adjustment Procedure (cont'd)

Example Program

```
10 !  RE-STORE "DC_ADJUST"
30    !This program performs the firmware-guided DC adjustment procedure
40    !for the E1445A Arbitrary Function Generator.  An 3458A DMM
50    !is required.
60    !
70    DIM Results(1:44)
80    INTEGER Cal_point,Max_cal_point,Problem,Err_num
90    !
100   !---------- Set up I/O paths ----------
110   ASSIGN @Afg TO 70910
120   ASSIGN @Dmm TO 722
130   !
140   !---------- Initialize variables ----------
150   Max_cal_point=44
160   Cal_point=0
170   Problem=0
180   Secure_code$="E1445A"
190   !
200   !---------- Initialize AFG and DMM ----------
210   OUTPUT @Afg;"*RST;*CLS"
220   OUTPUT @Dmm;"PRESET NORM"
230   !
240   !---------- Connections ----------
250   CLEAR SCREEN
260   PRINT "Connect the DMM to the AFG Output (4-wire connection)"
270   DISP "Press 'Continue' when ready"
280   PAUSE
290   CLEAR SCREEN
300   !
310   !---------- Setup AFG ----------
320   Cal_point=1
330   OUTPUT @Afg;"CAL:SEC:STATE OFF,"&Secure_code$ !Disable cal security
340   OUTPUT @Afg;"CAL:DC:BEGIN"                    !Begin DC cal
350   OUTPUT @Afg;"*OPC?"                           !Wait for previous command to finish
360   ENTER @Afg;Not_busy
370   !
380   !---------- Start of loop ----------
390   REPEAT
400      DISP "DC Calibration in progress:  Cal Point #"&VAL$(Cal_point)
410      !
420      GOSUB Setup_dmm                            !Change DMM settings, if necessary
430      GOSUB Read_dmm                             !Get reading
440      !
```

(Continued on next page)

Example Program (cont'd)

```
450      IF Cal_point=30 THEN                              !Special case -- set range now
460        OUTPUT @Dmm;"RANGE 10"
470      END IF
480      !
490      OUTPUT @Afg;"CAL:DC:POINT? ";Reading              !Send cal value to AFG
500      ENTER @Afg;This_point,Err_num                     !Returns current point,err code
510      WAIT .5
520      !
530      Results(Cal_point)=PROUND(Reading,-5)
540      Cal_point=Cal_point+1                             !Increment Cal_point
550    UNTIL (Err_num<>0) OR (Cal_point>Max_cal_point)
560    !
570    !---------- End of loop ----------
580    !If error, print error number & cal point, else send PUD string
590    IF Err_num=0 THEN
600      PRINT "Calibration Successful"
610      !
620      !Store cal information if desired - place desired data inside quotes
630      !in following line and remove !'s.
640 !    Pud$="63 CHARACTERS MAX"                          !Change Pud$ as desired
650 !    OUTPUT @Afg;"*PUD #0"&Pud$;CHR$(10);END
660    ELSE
670      PRINT "Calibration Error Number "&VAL$(Err_num)&" at Cal Point "&VAL$(Cal_point-1)
680    END IF
690    DISP
700    !
710    !---------- Quit ----------
720    PAUSE
730    OUTPUT @Afg;"CAL:SEC:STATE ON"                      !Enable cal security
740    OUTPUT @Afg;"*RST"                                  !Reset AFG
750    OUTPUT @Dmm;"RESET"
760    LOCAL @Dmm                                          !Return DMM to local control
770    !
780    ASSIGN @Afg TO *
790    ASSIGN @Dmm TO *
800    STOP                                                !End of main program
810    !
820    !---------- Subroutines ----------
830    !
840 Setup_dmm:     !
850    SELECT Cal_point
860    CASE =1                                             !Cal point 1
870      OUTPUT @Dmm;"FUNC DCV;RANGE 10;NPLC 10;OCOMP OFF"
880    CASE =29                                            !Cal point 29
890      OUTPUT @Dmm;"RANGE 1;NPLC 1"
```

(Continued on next page)

DC Adjustment Procedure (cont’d)

Example Program (cont’d)

```
900  CASE =31                                        !Cal point 31
910    OUTPUT @Dmm;"RANGE 10"
920  CASE =33                                        !Cal point 33
930    OUTPUT @Dmm;"RANGE .1"
940  CASE =41,=43                                    !Cal point 41,43
950    OUTPUT @Dmm;"FUNC DCV;RANGE .1"
960    GOSUB Read_dmm                                !Read voltage - this will
970                                                  !Determine ohms range for
980                                                  !Measurements that follow
990                         !
1000   OUTPUT @Dmm;"FUNC OHMF;OCOMP ON"
1010   !
1020   !Determine proper DMM range, using rdg from a few lines up
1030   SELECT ABS(Reading)                           !Use previous Rdg
1040   CASE <=1.0E-2                                 !If Rdg<=10mV,
1050     OUTPUT @Dmm;"RANGE 100"
1060   CASE <=1.0E-1                                 !IF 10mV<Rdg<=100mV,
1070     OUTPUT @Dmm;"RANGE 1000"
1080   CASE ELSE                                     !IF Rdg>100mV,
1090     Problem=1                                   !Something is wrong
1100   END SELECT
1110 END SELECT
1120 RETURN
1130 !
1140 Read_dmm:   !
1150 OUTPUT @Dmm;"TRIG SGL"
1160 ENTER @Dmm;Reading                              !Get reading
1170 Reading=PROUND(Reading,-10)
1180 RETURN
1190 !
1200 END
```

AC Flatness Adjustment Procedure - 250 kHz Filter

Description

This procedure adjusts the AC calibration constants for the 250 kHz filter. The AC Flatness Test for the 250 kHz filter (see Chapter 2) is performed with AC corrections disabled. The results are used to calculate new calibration constants, which are then transferred to non-volatile memory.

Preliminary Procedure

- Perform a complete autocalibration on the DMM (unless an autocal has been performed within the last 24 hours).
- Determine the calibration constants by performing Test 2-5 (see Chapter 2), with the following modification: After resetting the AFG (step 1), turn off AC corrections using the CAL:STAT:AC OFF command.

Adjustment Procedure

1. Disable calibration security on the AFG:

   CAL:SEC:STAT OFF, <security code> *Cal security off*

   where <code> is the AFG's security code (factory-set to "E1445A").

2. Verify that the calibration constants determined in the Preliminary Procedure are acceptable (see SUB Valid_cons in the example program).

3. Transfer the calibration constants to the AFG in arbitrary block data format:

   CAL:DATA:AC1 <data > *Transfer cal constants*

NOTE *See SUB Adj_flat in the example program to see how step 3 is performed in Agilent BASIC.*

Example Program

An example program that performs the AC flatness adjustment procedures for both filters is listed following the AC flatness adjustment procedure for the 10 MHz filter.

AC Flatness Adjustment Procedure - 10 MHz Filter

Description

This procedure adjusts the AC calibration constants for the 10 MHz filter. The AC Flatness Test for the 10 MHz filter (see Chapter 2) is performed with AC corrections disabled. The results are used to calculate new calibration constants, which are then transferred to non-volatile memory.

Preliminary Procedure

- Perform a complete autocalibration on the DMM (unless an autocal has been performed within the last 24 hours).
- Follow the manufacturer's instructions for calibrating the Power Meter and correcting for the Power Sensor.
- Determine the calibration constants by performing Test 2-6 (see Chapter 2), with the following modification: After resetting the AFG (step 1), turn off AC corrections using the CAL:STAT:AC OFF command.

Adjustment Procedure

1. Disable calibration security on the AFG:

   CAL:SEC:STAT OFF, <security code> *Cal security off*

   where <security code> is the AFG's security code (factory-set to "E1445A").

2. Verify that the calibration constants determined in the Preliminary Procedure are acceptable (see SUB Valid_cons in the example program).

3. If the firmware revision is A.02.00 or higher (use the *IDN? command to determine the firmware revision), transfer the two constants (4 and 25000) that determine the frequencies to be calibrated:

   CAL:DATA:FILT <data>

NOTE

See SUB Load_magic_num in the example program to see how step 3 is performed in Agilent BASIC.

Adjustment Procedure (cont'd)

NOTE

*Rev A.02.00 (use the *IDN? command to determine the firmware revision) allows the 10 MHz filter to be replaced with a filter that has a lower cutoff frequency (the 10 MHz filter must be replaced at the factory). If the 10 MHz filter has been replaced, change the value for Max_freq in line 570 of the example program to the new cutoff frequency. Changing Max_freq may change the constants that are sent with the CAL:DATA:FILT command in step 3 (see SUB Load_magic_num).*

4. Transfer the calibration constants to the AFG in arbitrary block data format:

   CAL:DATA:AC2 <data > *Transfer cal constants*

NOTE

See SUB Adj_flat in the example program to see how step 4 is performed in Agilent BASIC.

Example Program

```
10!   RE-STORE "AC_FLAT"
30    !This program performs the AC flatness adjustment procedure for
40    !the E1445A Arbitrary Function Generator. An 3458A DMM
50    !and an Agilent 8902A Measuring Receiver are required.
60    !
70    !To perform the flatness measurements without adjustments, change
80    !Mode$ to "M" below.
90    !
100   COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$[12]
110   COM /Flat/ INTEGER Num_points,Max_con
120   CLEAR SCREEN
130   !
140   !---------- Set up I/O paths ----------
150   ASSIGN @Afg TO 70910
160   ASSIGN @Dmm TO 722
170   ASSIGN @Pwr_mtr TO 714
180   Mode$="M"                                  !'M' means measure, 'A' means adjust
190   Secure_code$="E1445A"                      !Calibration security code
200   !
210   CALL Flatness("250KHZ",Mode$)
220   CALL Flatness("10MHZ",Mode$)
230   !
240   !---------- QUIT ----------
250   !RESET INSTRUMENTS
260   OUTPUT @Afg;"*RST;*CLS"
270   OUTPUT @Pwr_mtr;"IP"
280   OUTPUT @Dmm;"RESET"
290   LOCAL @Dmm
300   LOCAL @Pwr_mtr
310   !
320   !CLOSE I/O PATHS
330   ASSIGN @Afg TO *
340   ASSIGN @Dmm TO *
350   ASSIGN @Pwr_mtr TO *
360   STOP
370   !
380   END
390   !
400   !******************** End Of Main Program ********************
410   !
```


(Continued on next page)

Example Program (cont'd)

```
420 Flatness:SUB Flatness(Filter$,Mode$)
430     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
440     COM /Flat/ INTEGER Num_points,Max_con
450     INTEGER Filter,Ac_cal_int(1:2)
460     CLEAR SCREEN
470     !
480     !---------- Initialize variables ----------
490     Ampl_dbm=24                                     !AFG max amplitude
500     !
510     !---------- Main Program ----------
520     IF Filter$="250KHZ" THEN
530       Num_points=25                                 !Number of test points
540       Max_freq=2.50E+5
550     ELSE                                            !Else, 10M filter will be used
560       Num_points=27                                 !Number of test points
570       Max_freq=1.08E+7
580     END IF
590     PRINT "FILTER = "&Filter$
600     !
610     ALLOCATE Test_freq(1:Num_points),Results(1:Num_points)
620     !
630     !Determine test frequencies
640     Step_size=Max_freq/Num_points
650     FOR I=1 TO Num_points
660       Test_freq(I)=Step_size*I
670     NEXT I
680     !
690     GOSUB Setup_afg
700     CALL Meas_flat(Test_freq(*),Results(*),Filter$)
710     !
720     IF Mode$="A" THEN
730       CALL Adj_flat(Results(*),Filter$,Test_freq(Num_points))
740     END IF
750     !
760     DEALLOCATE Test_freq(*),Results(*)
770     SUBEXIT
780     !
790 Setup_afg:   !
800     OUTPUT @Afg;"*RST;*CLS"
810     WAIT .5
820     !
```

(Continued on next page)

Example Program (cont'd)

```
830      OUTPUT @Afg;"FUNC SIN;";                          !Sine
840      OUTPUT @Afg;":VOLT "&VAL$(Ampl_dbm)&"DBM;";   !Set amplitude
850      OUTPUT @Afg;":OUTP:LOAD 50                        !50 ohm load
860      OUTPUT @Afg;"CAL:STATE:AC "&VAL$(Mode$="M") !Turn AC corrections
870                                                        !On if meas mode, or
880                                                        !Off if adjust mode
890      OUTPUT @Afg;"OUTP:FILT:FREQ "&Filter$             !Set filter
900      OUTPUT @Afg;"OUTP:FILT ON"
910      OUTPUT @Afg;"INIT:IMM"
920      WAIT 1
930      RETURN
940   SUBEND
950   !
960 Meas_flat:SUB Meas_flat(Test_freq(*),Results(*),Filter$)
970      COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
980      COM /Flat/ INTEGER Num_points,Max_con
990      INTEGER Dmm_setup,Pm_setup
1000      !
1010      !---------- Initialize variables ----------
1020      Ref_freq=1000                                    !Reference frequency
1030      Xover_freq=1.E+5                                 !Crossover frequency
1040      Dmm_setup=1
1050      Pm_setup=1
1060      !
1070      !---------- Get ref readings ----------
1080      !
1090      PRINTER IS CRT
1100      !Get DMM reading at ref freq
1110      OUTPUT @Afg;"FREQ "&VAL$(Ref_freq)
1120      CALL Dmm_flat_rdg(Ref_freq,Dmm_ref,Dmm_setup)
1130      PRINT "DMM REF READING =";Dmm_ref
1140      !
1150      !If 10MHZ filter, get DMM & PWR MTR readings at crossover freq
1160      IF Filter$="10MHZ" THEN
1170         OUTPUT @Afg;"FREQ "&VAL$(Xover_freq)
1180         !
1190         CALL Dmm_flat_rdg(Xover_freq,Dmm_xover,Dmm_setup)
1200         PRINT "DMM XOVER READING =";Dmm_xover
1210         CALL Pm_flat_rdg(Xover_freq,Pm_xover,Pm_setup)
1220         Correct_factor=Dmm_xover/Pm_xover
1230         PRINT "POWER METER XOVER READING =";Pm_xover
1240      ELSE
1250         Correct_factor=1
1260      END IF
```

(Continued on next page)

AC Flatness Adjustment Procedure (cont'd)

Example Program (cont'd)

```
1270     Offset_factor=Dmm_ref
1280     PRINT "CORRECTION FACTOR =";Correct_factor
1290     PRINT
1300     PRINT
1310     PRINTER IS CRT
1320     !
1330     !
1340     !---------- Perform measurements at test freqs ----------
1350     !
1360     PRINT "    FREQ     READING (V)     ERROR (dBm)"
1370     PRINT "    ----     -----------     -----------"
1380     PRINT
1390     !
1400     FOR I=1 TO Num_points
1410     !Set AFG to test freq
1420       IF Test_freq(I)>1.073741824E+7 THEN          !SCPI can't do 10.8MHz
1430         GOSUB Max_afg_freq                         !so use register commands
1440       ELSE
1450         OUTPUT @Afg;"FREQ "&VAL$(Test_freq(I))
1460       END IF
1470       !
1480       !Get reading
1490       IF Filter$="250KHZ" THEN                     !If 250K filter,
1500         CALL Dmm_flat_rdg(Test_freq(I),Reading,Dmm_setup)
1510       ELSE                                         !If 10M filter,
1520         CALL Pm_flat_rdg(Test_freq(I),Reading,Pm_setup)
1530       END IF
1540       Flat_result=Reading*Correct_factor           !Adjust reading
1550       !Convert to dBm error
1560       Flat_error_dbm=PROUND((20*LGT(Flat_result)+13.0103)-(20*LGT(Offset_factor)+13.0103),-4)
1570       Results(I)=Flat_error_dbm                    !Store result in array
1580       !
1590       Freq$=FNFormat_num$(Test_freq(I),1.E+5,9,"M6D","MD.2DESZ")
1600       Result_v$=FNFormat_num$(Flat_result,1.E+3,9,"M2D.5D","MD.3DESZ")
1610       Result_dbm$=FNFormat_num$(Flat_error_dbm,10,9,"M2D.5D","MD.3DESZ")
1620       PRINT USING "9A,5X,9A,5X,9A";Freq$,Result_v$,Result_dbm$
1630     NEXT I                                         !End of loop
1640     PRINT
1650     SUBEXIT
1660     !
1670 Max_afg_freq: !Set AFG to 10.8MHz with register level commands
1680     OUTPUT @Afg;"FREQ MAX"                         !Get close with SCPI
```

(Continued on next page)

Example Program (cont'd)

```
1690     !Use register commands to get to 10.8MHz
1700     OUTPUT @Afg;"DIAG:POKE #HE000A1,8,0"           !PHASE_A1,0
1710     OUTPUT @Afg;"DIAG:POKE #HE000A3,8,126"         !PHASE_A2,126
1720     OUTPUT @Afg;"DIAG:POKE #HE000A5,8,95"          !PHASE_A3,95
1730     OUTPUT @Afg;"DIAG:POKE #HE000A7,8,64"          !PHASE_A4,64
1740     OUTPUT @Afg;"DIAG:POKE #HE0008D,8,0"           !LDSTBIND,0
1750     WAIT .1
1760     RETURN
1770  SUBEND
1780  !
1790 Adj_flat:SUB Adj_flat(Results(*),Filter$,Max_freq)
1800     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
1810     COM /Flat/ INTEGER Num_points,Max_con
1820     INTEGER Cal_problem,Problem
1830     !
1840     Cal_problem=0
1850     Scale_factor=1000
1860     STATUS @Afg,3;Address                          !Get path address
1870     !
1880     ALLOCATE INTEGER Ac_cal_cons(1:Num_points)
1900     FOR I=1 TO Num_points
1910       Ac_cal_cons(I)=Results(I)*Scale_factor       !Scale results array
1920     NEXT I
1930     !
1940     CALL Valid_cons(Results(*),Cal_problem)        !Make sure constants are within range
1960     !Transfer "magic numbers" if 10MHz filter
1970     IF Filter$<>"250KHZ" THEN
1980       Load_magic_num(Max_freq,Problem)
1990       IF Problem THEN
2000         PRINT "Problem occurred in Load_magic_num."
2010         Cal_problem=1
2020       END IF
2030     END IF
2040     !
2050     IF NOT Cal_problem THEN
2060       OUTPUT @Afg;"ABORT"                          !Abort waveform
2070       !
2080       !Store cal constants into eeprom (format off)
2090       OUTPUT @Afg;"CAL:SEC:STATE OFF,"&Secure_code$      !Enable cal
2100       ASSIGN @Afg TO Address;FORMAT OFF
2110       IF Filter$="250KHZ" THEN
2120         PRINT "Changed 250KHz Cal constants"
2130         OUTPUT @Afg USING "#,K";"CAL:DATA:AC1 #0"
2140       ELSE
2150         PRINT "Changed 10MHz Cal constants"
2160         OUTPUT @Afg USING "#,K";"CAL:DATA:AC2 #0"
2170       END IF
```

(Continued on next page)

Example Program (cont’d)

```
2180        OUTPUT @Afg;Ac_cal_cons(*)                   !Load array
2190        OUTPUT @Afg USING "#,K";CHR$(10),END         !LF,EOI
2200        !
2210        ASSIGN @Afg TO Address                       !Back to default attributes
2220        OUTPUT @Afg;"CAL:SEC:STATE ON"               !Disable cal
2230        !
2240        PRINT "Flatness calibration constants stored to EEPROM"
2250      ELSE
2260        PRINT "Flatness calibration constants NOT stored to EEPROM"
2270      END IF
2280      !
2290      DISP "Press ’Continue’ when ready"
2300      PAUSE
2310      DISP
2320      !
2330      DEALLOCATE Ac_cal_cons(*)
2340  SUBEND
2350  !
2360 Dmm_flat_rdg:SUB Dmm_flat_rdg(Freq,Rdg,INTEGER Dmm_setup)
2370      COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
2380      COM /Flat/ INTEGER Num_points,Max_con
2390      !
2400      IF Dmm_setup THEN                              !If true, set up DMM
2410                                                     !otherwise, skip setup
2420        DISP "Connect DMM to AFG Output (with 50ohm termination), then press ’Continue’"
2430        PAUSE
2440        DISP
2450        OUTPUT @Dmm;"PRESET NORM;FUNC ACV;SETACV SYNC;TRIG HOLD"
2460        OUTPUT @Dmm;"RANGE 10;DELAY .1"
2470        WAIT 1
2480        Dmm_setup=0                                  !Clear flag so setup is only performed once
2500      END IF
2510      !
2520      OUTPUT @Dmm;"ACBAND "&VAL$(Freq*.9)&","&VAL$(Freq*1.1)
2530      WAIT .5
2540      OUTPUT @Dmm;"TRIG SGL"
2550      ENTER @Dmm;Rdg
2560  SUBEND
2570  !
2580 Pm_flat_rdg:SUB Pm_flat_rdg(Freq,Rdg,INTEGER Pm_setup)
2590      COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
2600      COM /Flat/ INTEGER Num_points,Max_con
2610      !
2620      IF Pm_setup THEN                               !If true, then set up Power Meter
2630                                                     !otherwise skip setup
```

(Continued on next page)

Example Program (cont’d)

```
2640        DISP "Connect Power Meter to AFG Output, then press ’Continue’"
2650        PAUSE
2660        DISP
2670        OUTPUT @Pwr_mtr;"IP"                            !Instrument preset
2680        OUTPUT @Pwr_mtr;"AU M4 WT"                      !Auto operation, RF power, watts
2690        WAIT .5
2700        Pm_setup=0                                      !Clear flag so that setup
2710                                                        !is only performed once
2720     END IF
2730     OUTPUT @Pwr_mtr;VAL$(Freq/1.E+6)&"MHZ"             !Expected frequency
2740     OUTPUT @Pwr_mtr;"T3"                               !Trigger Pwr Meter w/settling
2750     ENTER @Pwr_mtr;Rdg                                 !Get reading
2760     !
2770     Rdg=SQRT(ABS(Rdg)*50)                              !Convert from watts to volts
2780  SUBEND
2790  !
2800 Read_dc_cal_con:SUB Read_dc_cal_con(Cal_real(*))
2810     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
2820     COM /Flat/ INTEGER Num_points,Max_con
2830     !
2840     Max_con=25
2850     ALLOCATE Scale(1:12),INTEGER Cal_reflect(1:Max_con)
2860     IF SIZE(Cal_real,1)<Max_con THEN
2870        PRINT "PASS PARAMETER NOT DIMENSIONED LARGE ENOUGH"
2880        BEEP
2890     END IF
2900     !
2910     !SET CAL CONSTANT SCALE FACTORS
2920     DATA 7E6   ,7E6    ,1E7  ,1E7  ,1E6
2930     !    M_plus,M_minus,M_adj,M_off,M_cust
2940     DATA 1E6   ,1E6    ,1E10 , 1E6 , 1E4
2950     !    Vpwr  ,Vbuf   ,M_sub, B_sum, dB ERROR
2960     DATA  4    , 0
2970     !  P&N BASE
2980     READ Scale(*)
2990     !
3000     OUTPUT @Afg;"CAL:SEC:STATE OFF,"&Secure_code$
3010     !
3020     !Read cal constants back
3030     OUTPUT @Afg;"CAL:DATA?"
3040     ENTER @Afg USING "4A,34(W)";Dummy$[1,4],Cal_reflect(*)
3050     !
3060     OUTPUT @Afg;"CAL:SEC:STATE ON"
3070     !
```

(Continued on next page)

Example Program (cont'd)

```
3080     FOR I=1 TO Max_con
3090       Cal_real(I)=Cal_reflect(I)
3100       IF I=1 THEN Cal_real(I)=Cal_reflect(I)/Scale(1)        ! M_plus
3110       IF I=2 THEN Cal_real(I)=Cal_real(I)/Scale(11)          ! P_base
3120       IF I=3 THEN Cal_real(I)=Cal_reflect(I)/Scale(2)        ! M_minus
3130       IF I=4 THEN Cal_real(I)=Cal_reflect(I)/Scale(3)        ! M_adj
3140       IF I=5 THEN Cal_real(I)=Cal_real(I)/Scale(11)          ! N_base
3150       IF I>5 AND I<13 THEN Cal_real(I)=Cal_real(I)/Scale(10)      !Filter and
3160                                                                   ! ATTN gain errors
3170       IF I=13 THEN Cal_real(I)=Cal_reflect(I)/Scale(4)       ! M_off
3180       IF I=14 THEN Cal_real(I)=Cal_reflect(I)/Scale(5)       ! M_cust
3190       IF I=15 THEN Cal_real(I)=Cal_reflect(I)/Scale(6)       ! Vpwro
3200       IF I=16 THEN Cal_real(I)=Cal_reflect(I)/Scale(6)       ! Vpwri
3210       IF I=17 THEN Cal_real(I)=Cal_reflect(I)/Scale(7)       ! Vbuf
3220       IF I=18 THEN Cal_real(I)=Cal_reflect(I)/Scale(8)       ! M_sum
3230       IF I=19 THEN Cal_real(I)=Cal_reflect(I)/Scale(9)       ! B_sum
3240                                                              ! Z_inc_0db (not scaled)
3250                                                              ! Z_inc_14db (not scaled)
3260       IF I>21 THEN Cal_real(I)=Cal_real(I)/Scale(10)         ! Zout gain errors
3270     NEXT I
3280     !
3290     DEALLOCATE Scale(*),Cal_reflect(*)
3300   SUBEND
3310   !
3320 Valid_cons:SUB Valid_cons(Results(*),INTEGER Cal_problem)
3330     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
3340     COM /Flat/ INTEGER Num_points,Max_con
3360     Max_con=25
3370     Cal_problem=0
3380     !
3390     ALLOCATE Cal_real(1:Max_con)
3400     !
3410     CALL Read_dc_cal_con(Cal_real(*))
3420     !CHECK FOR VALID CAL
3430     M_plus=Cal_real(1)                                       ! key cal constant
3440     P_base=Cal_real(2)                                       ! +base
3450     M_minus=Cal_real(3)                                      ! key cal constant
3460     M_adj=Cal_real(4)                                        ! key cal constant
3470     N_base=Cal_real(5)                                       ! -base
3480     !
3490     !Check that cal constants are reasonable--if not, use nominal values
3500     IF (M_plus<-.005 OR M_plus>-.003) THEN M_plus=-3.834E-3
3510     IF (M_minus<-.005 OR M_minus>-.003) THEN M_minus=-3.834E-3
3520     IF (M_adj<-.0012 OR M_adj>-.0009) THEN M_adj=-.001021
3530     IF (P_base<3180 OR P_base>3889) THEN P_base=3535
3540     IF (N_base<10 OR N_base>245) THEN N_base=128
3550     !
```

(Continued on next page)

Example Program (cont'd)

```
3560    !Check for valid cal
3570    Max_filter_db=MAX(Cal_real(6),Cal_real(7),0)
3580    Min_filter_db=MIN(Cal_real(6),Cal_real(7),0)
3590    !
3600    Max_attn_db=0
3610    Min_attn_db=0
3620    FOR I=8 TO 12
3630      IF Cal_real(I)>0 THEN
3640        Max_attn_db=Max_attn_db+Cal_real(I)
3650      ELSE
3660        Min_attn_db=Min_attn_db+Cal_real(I)
3670      END IF
3680    NEXT I
3690    !
3700    Max_zout_db=MAX(Cal_real(22),Cal_real(23),Cal_real(24),Cal_real(25),0)
3710    Min_zout_db=MIN(Cal_real(22),Cal_real(23),Cal_real(24),Cal_real(25),0)
3720    !
3730    Max_pos_gain_db=-1*MAX(Results(*),0)-(Max_filter_db+Max_attn_db+Max_zout_db)-1.02
3740    Min_pos_gain_db=-1*MIN(Results(*),0)-(Min_filter_db+Min_attn_db+Min_zout_db)-1.02
3750    !
3760    !Calculate P_inc's and N_inc's
3770    Max_p_inc=10*(10^((Max_pos_gain_db)/20)-1)/M_plus
3780    Min_p_inc=10*(10^((Min_pos_gain_db)/20)-1)/M_plus
3790    Max_n_inc=(Max_p_inc*(M_plus-M_minus))/M_adj
3800    Min_n_inc=(Min_p_inc*(M_plus-M_minus))/M_adj
3810    Max_gain_dac=P_base+Max_p_inc
3820    Min_gain_dac=P_base+Min_p_inc
3830    Max_to_dac=N_base+Max_n_inc
3840    Min_to_dac=N_base+Min_n_inc
3850    !
3860 !  PRINT "GAIN DAC EXTREMES: MAX,MIN = "&VAL$(PROUND(Max_gain_dac,-1))&" ,
"&VAL$(PROUND(Min_gain_dac,-1))
3870 !  PRINT "TURNOVER DAC EXTREMES: MAX,MIN = "&VAL$(PROUND(Max_to_dac,-1))&" ,
"&VAL$(PROUND(Min_to_dac,-1))
3880    !
3890    IF Max_gain_dac>4075 OR Min_gain_dac<20 THEN    ! If out of range
3900      Cal_problem=1                                ! Set flag
3910      PRINT "GAIN DAC OUT OF RANGE"
3920    END IF
3930    !
3940    IF Max_to_dac>247 OR Min_to_dac<8 THEN          ! If out of range
3950      Cal_problem=1                                ! Don't store constants
3960      PRINT "TURNOVER DAC OUT OF RANGE"
3970    END IF
3980    !
3990    DEALLOCATE Cal_real(*)
4000  SUBEND
4010  !
```

(Continued on next page)

Example Program (cont'd)

```
4020  SUB Syst_err(Address)
4030     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
4040     COM /Flat/ INTEGER Num_points,Max_con
4050     DIM Message$[256]
4060     REPEAT
4070        OUTPUT Address;"SYST:ERR?"
4080        ENTER Address;Code,Message$
4090        PRINT Code,Message$
4100     UNTIL NOT Code
4110  SUBEND
4120  !
4130 Load_magic_num:SUB Load_magic_num(Max_freq,OPTIONAL INTEGER Problem)
4140     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
4150     COM /Flat/ INTEGER Num_points,Max_con
4160     INTEGER Num_cal_points,N,Div
4170     ALLOCATE Id$[50],INTEGER Block(1:2),Ac_int(1:2)
4180     !
4190     !Check firmware rev - if A.01.00 then exit
4200     OUTPUT @Afg;"*IDN?"
4210     ENTER @Afg;Id$
4220     IF POS(Id$,"A.01.00") THEN SUBEXIT
4230     !
4240     STATUS @Afg,3;Address                          !Get path address
4250     !
4260     IF NPAR>1 THEN Problem=0
4270     Num_cal_points=27
4280     !
4290     Cal_step=Max_freq/Num_cal_points               !Step size
4300     !
4310     !Calculate N
4320     N=INT(LGT(Cal_step/32768)/LGT(2))+1
4330     N=MAX(N,1)
4340     N=MIN(N,8)
4350     !
4360     !Calculate Div
4370     Div=Cal_step/(2^N)
4380     Div=MAX(Div,1)
4390     Div=MIN(Div,32767)
4400     !
4410     IF Cal_step<>PROUND(((2^N)*Div),4) THEN
4420        IF NPAR>1 THEN Problem=1
```

(Continued on next page)

AC Flatness Adjustment Procedure (cont’d)

Example Program (cont’d)

```
4430     ELSE
4440        Block(1)=N
4450        Block(2)=Div
4460        !
4470        OUTPUT @Afg;"CAL:SEC:STATE OFF,"&Secure_code$      !Enable cal
4480        ASSIGN @Afg TO Address;FORMAT OFF
4490        OUTPUT @Afg USING "#,K";"CAL:DATA:FILTER #0"
4500        OUTPUT @Afg;Block(*)
4510        OUTPUT @Afg USING "#,K";CHR$(10),END
4520        ASSIGN @Afg TO Address                          !Back to default attributes
4530        OUTPUT @Afg;"CAL:SEC:STATE ON"                  !Disable cal
4540        !
4550        PRINT "MAGIC NUMBERS STORED: ";N,Div
4560        PRINT
4580     END IF
4590  SUBEND
4600  !
4610 Read_ac_cal_int:SUB Read_ac_cal_int(INTEGER Ac_cal_int(*))
4620     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
4630     COM /Flat/ INTEGER Num_points,Max_con
4640     !
4650     ALLOCATE Id$[50]
4660     !
4670     OUTPUT @Afg;"*IDN?"
4680     ENTER @Afg;Id$
4690     !
4700     IF POS(Id$,"A.01.00") THEN
4710        Ac_cal_int(1)=4
4720        Ac_cal_int(2)=25000
4730        SUBEXIT
4740     END IF
4750     !
4760     Max_con=2
4770     !
4780 !   IF SIZE(Ac_cal_int,1)<>Max_con OR RANK(Ac_cal_int)<>1 THEN
4790     !
4800     STATUS @Afg,3;Address
4810     !
4820     OUTPUT @Afg;"CAL:SEC:STATE OFF,"&Secure_code$
4830     OUTPUT @Afg;"CAL:DATA:FILTER?"
4840     ASSIGN @Afg TO Address;FORMAT OFF
4850     ENTER @Afg USING "3A,2(W)";Dummy$[1,3],Ac_cal_int(*)
4860     ASSIGN @Afg TO Address
4870     OUTPUT @Afg;"CAL:SEC:STATE ON"
4880     !
4890     PRINT Ac_cal_int(*)
4900  SUBEND
```

(Continued on next page)

AC Flatness Adjustment Procedure (cont’d)

Example Program (cont’d)

```
4910   !
4920  SUB Security_code
4930     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
4940     COM /Flat/ INTEGER Num_points,Max_con
4950     CLEAR SCREEN
4960     OUTPUT @Afg;"*RST;*CLS"
4970     !
4980     Valid=0
4990     REPEAT
5000        Secure_code$="E1445A"
5010        INPUT "Enter your security code <default is ’E1445A’>",Secure_code$
5020        Secure_code$=TRIM$(Secure_code$)
5030        Check_sec_code(Valid)
5040     UNTIL Valid
5050  SUBEND
5060  !
5070  !
5080  SUB Check_sec_code(Valid)
5090     COM @Afg,@Dmm,@Pwr_mtr,@Analyzer,Secure_code$
5100     COM /Flat/ INTEGER Num_points,Max_con
5110     DIM Message$[255]
5120     Valid=0
5130     CLEAR SCREEN
5140     DISP "Verifying security code..."
5150     WAIT 1
5160     OUTPUT @Afg;"CAL:SEC:STAT OFF,"&Secure_code$
5170     OUTPUT @Afg;"SYST:ERR?"
5180     ENTER @Afg;Code,Message$
5190     DISP
5200     !
5210     IF Code<>0 THEN
5220        BEEP 1000,.1
5230        PRINT "Invalid security code -- try again"
5240        OUTPUT @Afg;"*RST;*CLS"
5250        DISP "Press ’Continue’"
5260        PAUSE
5270        SUBEXIT
5280     ELSE
5290        Valid=1
5300        PRINT "Security code accepted"
5310        WAIT 1
5320        OUTPUT @Afg;"*RST;*CLS"
5330     END IF
5340     CLEAR SCREEN
5350  SUBEND
5360  !
5370  !
```

(Continued on next page)

AC Flatness Adjustment Procedure (cont’d)

Example Program (cont’d)

```
5380 Format_num:DEF FNFormat_num$(Value,Not_exp_max,INTEGER Length,Not_exp_img$,Exp_img$)
5390    INTEGER Diff
5400    SELECT ABS(Value)
5410    CASE <1.E-9,>=1.E+10
5420      IF NOT POS(Exp_img$,"ZZ") THEN
5430        OUTPUT String$ USING Exp_img$&"Z,#";Value
5440      ELSE
5450        OUTPUT String$ USING Exp_img$&",#";Value
5460      END IF
5470    CASE <1.E-4,>=Not_exp_max
5480      OUTPUT String$ USING Exp_img$&",#";Value
5490    CASE ELSE
5500      OUTPUT String$ USING Not_exp_img$&",#";Value
5510    END SELECT
5520    !
5530    Diff=Length-LEN(String$)
5540    IF Diff>0 THEN String$=RPT$(" ",Diff)&String$
5550    RETURN String$
5560  FNEND
5570  !
5580  !
```

Skew DAC Adjustment Procedure

Description

This procedure compensates for time delays between the AFG's two DACs. The skew setting which produces the lowest second harmonic amplitude is found and loaded into non-volatile memory.

Equipment Setup

- Connect the equipment as shown in Figure 3-3
- Set up the Spectrum Analyzer:

Center Frequency = 8 MHz
Frequency Span = 3.2 kHz

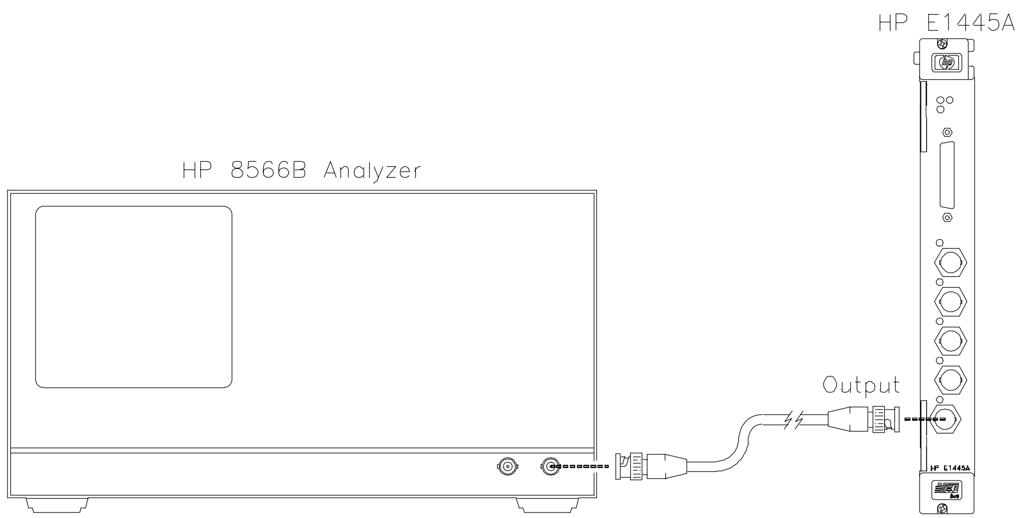

Figure 3-3. Skew DAC Adjustment Setup

Adjustment Procedure

1. Reset the AFG:

```
*RST
```

Adjustment Procedure (cont'd)

2. Set up the AFG to output an 11 dBm, 4 MHz sinewave:

```
FUNC SIN;
:VOLT 11 DBM;
:FREQ 4E6
INIT:IMM
```

3. Load an initial value of 128 into the delay DAC:

```
DIAG:POKE #HE0000B,8,2
DIAG:POKE #HE0000D,8,128
DIAG:POKE #HE0000B,8,7
DIAG:POKE #HE0000D,8,8
```

4. With the Spectrum Analyzer, locate and center the second harmonic. Then, reduce the frequency span to 2 kHz.

5. Find the delay DAC setting that minimizes the amplitude of the second harmonic (see the example program).

6. Disable calibration security on the AFG:

```
CAL:SEC:STAT OFF, <security code>          Cal security off
```

where <code> is the AFG's security code (factory-set to "E1445A").

7. Transfer the calibration constant (DAC setting) to the AFG in arbitrary block data format:

```
CAL:DATA:SKEW <data >                      Transfer cal constant
```

NOTE *See the example program to see how step 7 is performed in BASIC.*

---

8. Enable calibration security on the AFG:

```
CAL:SEC:STAT ON                            Cal security on
```

Example Program

```
10 !  RE-STORE "SKEW_CAL"
20    COM @Afg,@Analyzer,Secure_code$[20]
30    INTEGER Dac_bits,Dac_word,Min_word,Max_word,Step_size,Harmonic
40    INTEGER Loc_min,Cal_word,Search_loop,Max_search_loop,Filter,Skew_con
50    DIM Id$[50]
60    !
70    !---------- Assign I/O paths ----------
80    ASSIGN @Afg TO 70910
90    ASSIGN @Analyzer TO 718
100   !
110   !---------- Check firmware rev ----------
120   !Rev A.01.00 does not support this cal procedure
130   OUTPUT @Afg;"*IDN?"
140   ENTER @Afg;Id$
150   !
160   IF POS(Id$,"A.01.00") THEN
170      PRINT "This rev does not support skew DAC calibration."
180      STOP
190   END IF
200   !
210   !---------- Initialize variables ----------
220   Secure_code$="E1445A"                        !AFG security code
230   Harmonic=2                                   !Harmonic to be minimized
240   Filter=0                                     !No filter
250   Freq=4.E+6                                   !AFG frequency (Hz)
260   Amp_in_dbm=11                                !AFG amplitude (dBm)
270   Search_span$=VAL$(Freq*Harmonic*4.00E-4)     !Initial Spec Analyzer span
280   Test_span$="2000"                            !Span used for measurements
290   !
300   Dac_bits=8
310   Start_step_size=16
320   Step_size=Start_step_size
330   Max_search_loop=4
340   Dac_word=2^(Dac_bits-1)                      !Initial Dac_word
350   Max_word=2^(Dac_bits)                        !Initial max
360   Min_word=0                                   !Initial min
370   !
380   !---------- Test connections ----------
390   PRINT "Connect Spectrum Analyzer to AFG Ouput."
400   DISP "Press 'Continue' when ready"
410   PAUSE
420   CLEAR SCREEN
430   !
```

(Continued on next page)

Skew DAC Adjustment Procedure (cont’d)

Example Program (cont’d)

```
440  !---------- Perform cal ----------
450  OUTPUT @Afg;"*RST;*CLS;*OPC?"                    !Reset AFG
460  ENTER @Afg;Result
470  !
480  !Set up Spec Analyzer
490  Setup_spec(VAL$(Amp_in_dbm-2)&"DM",VAL$(Freq*Harmonic),Search_span$)
500  !
510  !Set up AFG
520  OUTPUT @Afg;"FUNC SIN;";
530  OUTPUT @Afg;":VOLT "&VAL$(Amp_in_dbm)&"DBM;";
540  OUTPUT @Afg;":FREQ "&VAL$(Freq)
550  OUTPUT @Afg;"INIT:IMM"
560  Load_delay_dac(Dac_word)                         !Load constant into register
570  !
580  !Capture and center 2nd harmonic
590  Get_2nd_harm(Test_span$)
600  !
610  !Begin cal search loop
620  Search_loop=1
630  REPEAT
640    ALLOCATE INTEGER Word_array(0:((Max_word-Min_word)/Step_size))
650    ALLOCATE REAL Meas_array(0:((Max_word-Min_word)/Step_size))
660    Array_counter=0
670    !
680    PRINT "LOOP =";Search_loop
690    PRINT
700    PRINT "CONSTANT","  READING"
710    PRINT "--------","  -------"
720    !
730    !Find constant that produces minimum 2nd harmonic
740    FOR I=Min_word TO Max_word STEP Step_size
750      IF I=256 THEN
760        Dac_word=255
770      ELSE
780        Dac_word=I
790      END IF
800      Load_delay_dac(Dac_word)                     !Load constant into register
810      Word_array(Array_counter)=Dac_word
820      !
830      !Measure 2nd_harmonic, store in array
840      Meas_2nd_harm(Meas_array(Array_counter))
850      PRINT Word_array(Array_counter),DROUND(Meas_array(Array_counter),8)
860      Array_counter=Array_counter+1
870    NEXT I
880    !
```

(Continued on next page)

Skew DAC Adjustment Procedure (cont'd)

Example Program (cont'd)

```
890      !Set variables for next loop
900      MAT SEARCH Meas_array,LOC MIN;Loc_min            !Get location of min rdg
910      Cal_word=Word_array(Loc_min)
920      Min_word=Word_array(MAX(0,Loc_min-1))
930      Max_word=Word_array(MIN((SIZE(Word_array,1)-1),Loc_min+1))
940      Step_size=Step_size/INT(SQRT(Start_step_size)+.5)   !Reduce step size
950      !
960      PRINT
970      PRINT
980      !
990      DEALLOCATE Meas_array(*),Word_array(*)
1000     Search_loop=Search_loop+1
1010  UNTIL Step_size<1
1020  !
1030  PRINT "CAL CONSTANT =";Cal_word
1040  PRINT
1050  Wrt_skew_con(Cal_word)                                  !Write word to eeprom
1060  !
1070  !---------- Quit ----------
1080  OUTPUT @Afg;"*RST;*CLS"
1090  ASSIGN @Afg TO *
1100  ASSIGN @Analyzer TO *
1110  STOP
1120  END
1130  !
1140 Load_delay_dac:SUB Load_delay_dac(INTEGER Delay_dac)
1150     COM @Afg,@Analyzer,Secure_code$
1160     INTEGER Lower_8,Benign_chn1
1170     !
1180     Benign_chn1=1
1190     Lower_8=BINAND(Delay_dac,255)
1200     !
1210     OUTPUT @Afg;"DIAG:POKE #HE0000B,8,2"
1220     OUTPUT @Afg;"DIAG:POKE #HE0000D,8,"&VAL$(Lower_8)
1230     OUTPUT @Afg;"DIAG:POKE #HE0000B,8,7"
1240     OUTPUT @Afg;"DIAG:POKE #HE0000D,8,"&VAL$(Benign_chn1+7)
1250     WAIT .1
1260  SUBEND
1270  !
```

(Continued on next page)

Example Program (cont'd)

```
1280 Wrt_skew_con:SUB Wrt_skew_con(INTEGER Cal_word)
1290     COM @Afg,@Analyzer,Secure_code$
1300     DIM Id$[50]
1310     !
1320     !Check firmware rev
1330     OUTPUT @Afg;"*IDN?"
1340     ENTER @Afg;Id$
1350     !
1360     IF POS(Id$,"A.01.00") THEN
1370        PRINT "This rev does not support skew DAC calibration."
1380        CALL Abort_error
1390     END IF
1400     !
1410     STATUS @Afg,3;Address                    !Get path address
1420     !
1430     OUTPUT @Afg;"CAL:SEC:STAT OFF,"&Secure_code$
1440     ASSIGN @Afg TO Address;FORMAT OFF
1450     OUTPUT @Afg USING "#,K";"CAL:DATA:SKEW #0"
1460     OUTPUT @Afg;Cal_word
1470     OUTPUT @Afg USING "#,K";CHR$(10),END
1480     ASSIGN @Afg TO Address
1490     OUTPUT @Afg;"CAL:SEC:STAT ON"
1500     !
1510     PRINT "Skew constant written to AFG."
1520  SUBEND
1530  !
1540 Setup_spec:SUB Setup_spec(Amp_in_dbm$,Center$,Span$)
1550     COM @Afg,@Analyzer,Secure_code$
1560     OUTPUT @Analyzer;"IP;RB 100HZ;VB 100HZ"  !Preset, set res & vid BW
1570     OUTPUT @Analyzer;"RL "&Amp_in_dbm$       !Set ref level
1580     OUTPUT @Analyzer;"SP "&Span$&"HZ"        !Set freq span
1590     OUTPUT @Analyzer;"CF "&Center$           !Set center frequency
1600  SUBEND
1610   !
1620 Get_2nd_harm:SUB Get_2nd_harm(Test_span$)
1630     COM @Afg,@Analyzer,Secure_code$
1640     OUTPUT @Analyzer;"S2;TS;E1"              !Peak search
1650     OUTPUT @Analyzer;"MKCF"                  !Center freq to marker
1660     OUTPUT @Analyzer;"SP "&Test_span$&"HZ"   !Narrow span
1670  SUBEND
1680  !
```

(Continued on next page)

Example Program (cont'd)

```
1690 Meas_2nd_harm:SUB Meas_2nd_harm(Reading)
1700      COM @Afg,@Analyzer,Secure_code$
1710      OUTPUT @Analyzer;"TS;E1"                          !Find peak
1720      OUTPUT @Analyzer;"MA"                             !Measure amplitude
1730      ENTER @Analyzer;Reading
1740  SUBEND
1750  !
1760 Read_skew_con:SUB Read_skew_con(INTEGER Skew_cal_con)
1770      COM @Afg,@Analyzer,Secure_code$
1780      ALLOCATE Id$[50]
1790      !
1800      OUTPUT @Afg;"*IDN?"
1810      ENTER @Afg;Id$
1820      IF POS(Id$,"A.01.00") THEN
1830         Skew_cal_con=128
1840         SUBEXIT
1850      END IF
1860      !
1870      STATUS @Afg,3;Address
1880      !
1890      OUTPUT @Afg;"CAL:SEC:STAT OFF,"&Secure_code$
1900      OUTPUT @Afg;"CAL:DATA:SKEW?"
1910      ASSIGN @Afg TO Address;FORMAT OFF
1920      ENTER @Afg USING "3A,1(W)";Dummy$[1,3],Skew_cal_con
1930      ASSIGN @Afg TO Address
1940      OUTPUT @Afg;"CAL:SEC:STAT ON"
1950  SUBEND
```

Chapter 4
Replaceable Parts

Introduction

This chapter contains information for ordering replaceable parts for the Agilent E1445A AFG.

Exchange Assemblies

Table 4-1 lists assemblies that may be replaced on an exchange basis (NEW/EXCHANGE ASSEMBLIES). Exchange 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.

Ordering Information

To order a part listed in Table 4-1, specify the Agilent part number and the quantity required. Send the order to your nearest Agilent Technologies Sales and Support Office.

Replaceable Parts List

Table 4-1 lists the user-replaceable parts for the Agilent E1445A AFG. See Figure 4-1 for locations of user-replaceable parts. Table 4-2 lists the reference designators for the AFG. Table 4-3 is the code list of manufacturers.

Table 4-1. Agilent E1445A Replaceable Parts

Reference Designator	Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
			NEW/EXCHANGE ASSEMBLIES		
	ME1445A	1	E1445A (NEW)	28480	ME1445A
	E1445-66201	1	E1445A (EXCHANGE)	28480	E1445-66201
			MECHANICAL PARTS		
HDL1	E1400-45102*	1	HANDLE-BOTTOM METAL INJECTION MOLDING	28480	E1400-45102*
HDL2	E1400-45101*	1	HANDLE-TOP METAL INJECTION MOLDING	28480	E1400-45101*
HDW010	0380-1858	2	STANDOFF-HEX .312-IN-LG 4-40-THD	05791	ST9532-36
HDW011	2190-0004	2	WASHER-LK INTL T NO. 4 .115-IN-ID	78189	SF 1904-00
HDW11-HDW15	2950-0054	5	NUT-HEX-DBL-CHAM 1/2-28-THD .125-IN-THK	28480	2950-0054
HDW17-HDW21	3050-0604	5	WASHER- 7/16 IN .5-IN-ID .75-IN-OD	86928	5710-94-16
MP1	8160-0686	1	CLIP-RFI STRIP-FINGERS BE-CU SN-PL	30817	00786-185
MP2-MP5	E1450-01202	4	EMI STRIP	28480	E1400-01202
PNL1	E1445-00202*	1	FRONT PANEL	28480	E1445-00202*
SCR1-SCR8	0515-1135	9	SCREW- MACHINE M3 X 0.5 25MM-LG -HD	28480	0515-1135
SCR10	0515-1135		SCREW- MACHINE M3 X 0.5 25MM-LG -HD	28480	0515-1135
SCR13-SCR14	E1400-00610*	2	SHOULDER SCREW ASSEMBLY	28480	E1400-00610*
SCR17	0515-0430	1	SCREW- MACHINE M3 X 0.5 6MM-LG PAN-HD	28480	0515-0430
SHD1	E1445-00601	1	TOP SHIELD	28480	E1445-00601
SHD2	E1445-00602*	1	BOTTOM SHIELD	28480	E1445-00602*
SHD3	E1445-00603	1	FLEX SHIELD	28480	E1445-00603
			A1 PRINTED CIRCUIT ASSEMBLY		
A1	E1445-63501	1	PCA- DAC MAIN	28480	E1445-63501
CR610-CR613	1990-1448	5	LED-LAMP ARRAY LUM-INT=1.5MCD, GREEN LENS	72619	553-0302
CR614	1990-1364	1	LED-LAMP ARRAY LUM-INT=300UCD, RED-GREEN LENS	72619	553-0321
CR615	1990-1448		LED-LAMP ARRAY LUM-INT=1.5MCD, GREEN LENS	72619	553-0302
CR616	1990-1507	1	LED-LAMP LUM-INT=800UCD IF=20MA-MAX, RED LENS	72619	553-0301
F301-F305	2110-0699	5	FUSE-SUBMINIATURE 5A 125V NTD AX UL CSA	75915	R251005T1
J2-J3	1251-5150	2	CONNECTOR-POST TYPE .100-PIN-SPCG 12-CONTACT	18873	67996-612
J101-J104	1252-4568	5	CONNECTOR-POST TYPE .100-PIN-SPCG 3-CONTACT	18873	89602-603
J105	1252-1201	1	CONNECTOR-RECT D-SUBMINIATURE 25-CONTACT	00779	748877-1
J106	1252-4568		CONNECTOR-POST TYPE .100-PIN-SPCG 3-CONTACT	18873	89602-603
J110-J113	1250-2012	4	CONNECTOR-RF BNC FEM PC-W-STDFS 50-OHM	00779	227676-1
JM1-JM7	1258-0209	7	JUMPER-REMOVABLE 2 POSITION; .250 IN	00779	531220-2
SP301-SP302	3101-2243	2	SWITCH-DIP ROCKER 8-1A 0.05A 30VDC	81073	76YY22318S
			A2 PRINTED CIRCUIT ASSEMBLY		
A2	E1445-63502	1	PCA- DAC ANALOG	28480	E1445-63502
J901	1250-2012	1	CONNECTOR-RF BNC FEM PC-W-STDFS 50-OHM	00779	227676-1
			A3 PRINTED CIRCUIT ASSEMBLY		
A3	E1445-63503	1	PCA- DIG TIMER	28480	E1445-63503
U501	1813-0879	1	CLOCK-OSCILLATOR-XTAL 40.0-MHZ 0.005%	28480	1813-0879
U502	1813-0831	1	CLOCK-OSCILLATOR-XTAL 42.949672-MHZ	28480	1813-0831

* These parts are not compatible with older versions of the E1445A that have plastic handles. To replace one of these parts on an older E1445A, you must order all five of the parts marked with a *.

Table 4-2. Agilent E1445A Reference Designators

E1445A Reference Designators	
A .... assembly	MP .... mechanical part
CR .... diode	PNL .... panel
HDL .... handle	SCR .... screw
HDW .... hardware	SHD .... shield
J .... electrical connector (jack)	SP .... switch
JM .... jumper	U .... integrated circuit
F...fuse	

Table 4-3. Agilent E1445A Code List of Manufacturers

Mfr. Code	Manufacturer's Name	Manufacturer's Address	Zip Code
00779	AMP INC	HARRISBURG, PA US	17111
05791	LYN-TRON INC	BURBANK, CA US	91505
18873	DUPONT E.I. DE NUMOURS & CO	WILMINGTON, DE US	19801
28480	AGILENT TECHNOLOGIES		
30817	INSTRUMENT SPECIALTIES INC	DEL WATER GAP, PA US	18327
72619	DIALIGHT CORP	BROOKLYN, NY US	11237
75915	LITTELFUSE INC	DES PLAINES, IL US	60016
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF	ELGIN, IL US	60126
81073	GRAYHILL INC	LA GRANGE, IL US	60525
83486	ELCO INDUSTRIES INC	ROCKFORD, IL US	61125
86928	SEASTROM MFG CO	GLENDALE, CA US	91201

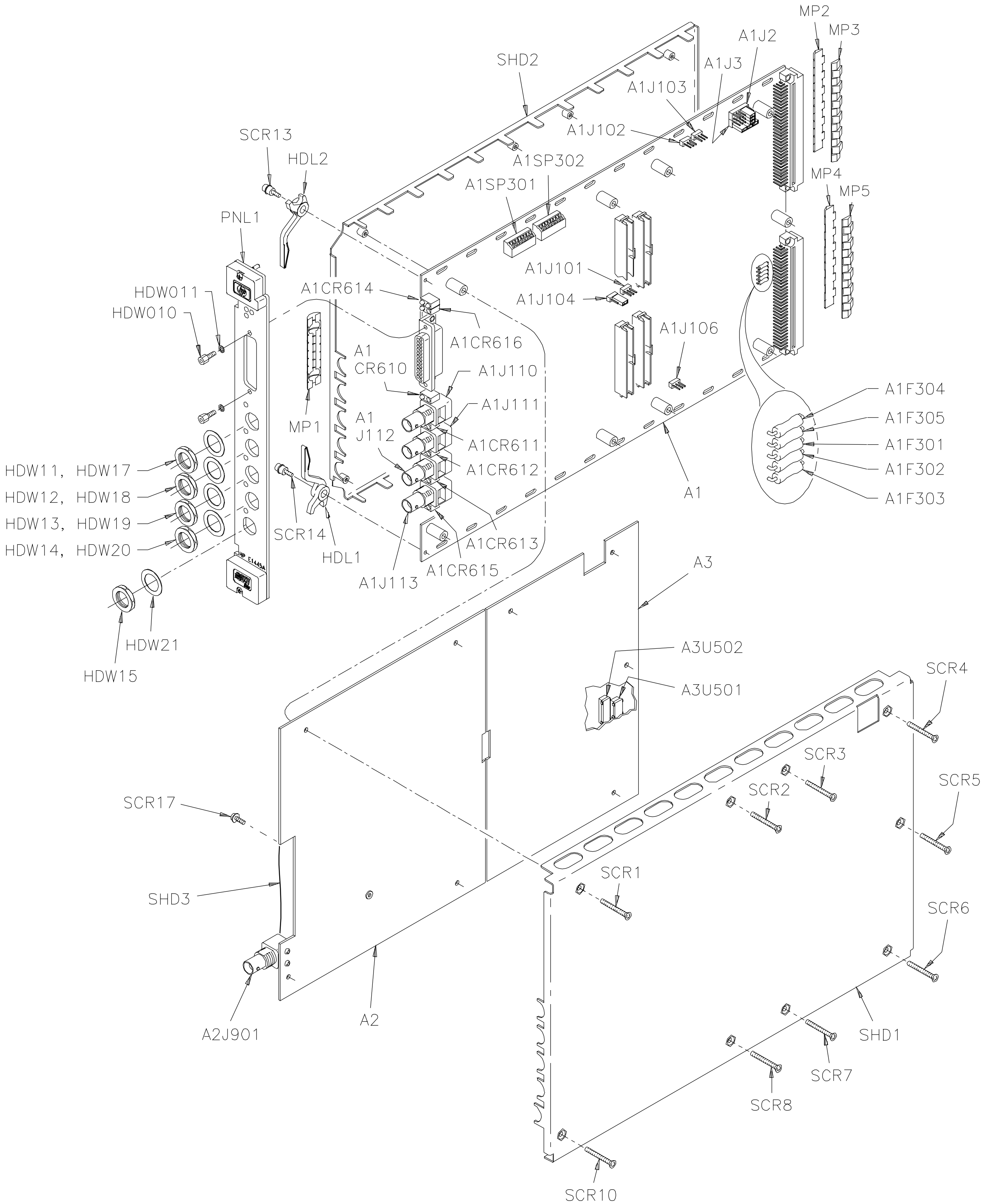

Figure 4-1. E1445A Replaceable Parts

Chapter 5
Service

Introduction

This chapter contains service information for the Agilent E1445A AFG, including troubleshooting guidelines and repair/maintenance guidelines.

WARNING **Do not perform any of the service procedures shown unless you are a qualified, service-trained technician, and have read the WARNINGS and CAUTIONS in Chapter 1.**

Equipment Required

Equipment required for AFG troubleshooting and repair is listed in Table 1-1, *Recommended Test Equipment*. Any equipment that satisfies the requirements given in the table may be substituted. To avoid damage to the screw head slots, use T8 and T10 Torx drivers as described in the disassembly instructions later in this chapter.

Service Aids

See Chapter 4 for descriptions and locations of Agilent E1445A replaceable parts. Service notes, manual updates, and service literature for the AFG may be available through Agilent. For information, contact your nearest Agilent Sales and Support Office.

Troubleshooting Techniques

Identifying the Problem

To troubleshoot an Agilent E1445A problem, you should first identify the problem, and then isolate the cause to a user-replaceable part.

AFG problems can be divided into three general categories:

- Operator errors
- Catastrophic failures
- Performance out of specification

Operator Errors

Apparent failures may result from operator errors. See Appendix B in the *Agilent E1445A User's Manual* for information on operator errors.

Catastrophic Failure

If a catastrophic failure occurs, see "Testing the Assembly" to troubleshoot the AFG.

Performance Out of Specification

If the AFG fails any of its Performance Tests, perform the adjustments described in Chapter 3, then repeat the Performance Tests.

Testing the Assembly

You can use the tests and checks in Table 5-1 to isolate the problem. See Figure 4-1 in Chapter 4 for locations of user-replaceable parts.

Table 5-1. Agilent E1445A Tests/Checks

Test/Check	Reference Designator	Check:
Heat Damage	- - - - - - - - - -	Discolored PC boards Damaged insulation Evidence of arcing
AFG/Jumper Settings	A1BG0 - A1BG3 A1SP301 A1SP302	Bus Request level setting LADDR setting Servant Area setting
AFG PCAs	A1F301 - A1F305	Fuse continuity Damaged connectors

Checking for Heat Damage

Inspect the AFG for signs of abnormal internally generated heat such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing. If there is damage, do not operate the AFG until you have corrected the problem.

Checking Switches/Jumpers

Verify that the logical address setting is set correctly (factory set at 80). Verify that the bus request level and servant area settings are correct. See the *Agilent E1445A User's Manual* for information.

Checking the AFG PCAs

Check fuse continuity and inspect all connectors for bent pins or damaged contacts.

Disassembly

Use the following procedure to disassemble the AFG (see Figure 5-1):

1. Remove the nine T10 Torx screws on the right side panel.
2. Remove the front panel handles using a T-8 TORX driver.
3. Remove the hex standoffs and washers from the front panel digital port connector.
4. Remove the nuts and washers from the front panel BNC's.

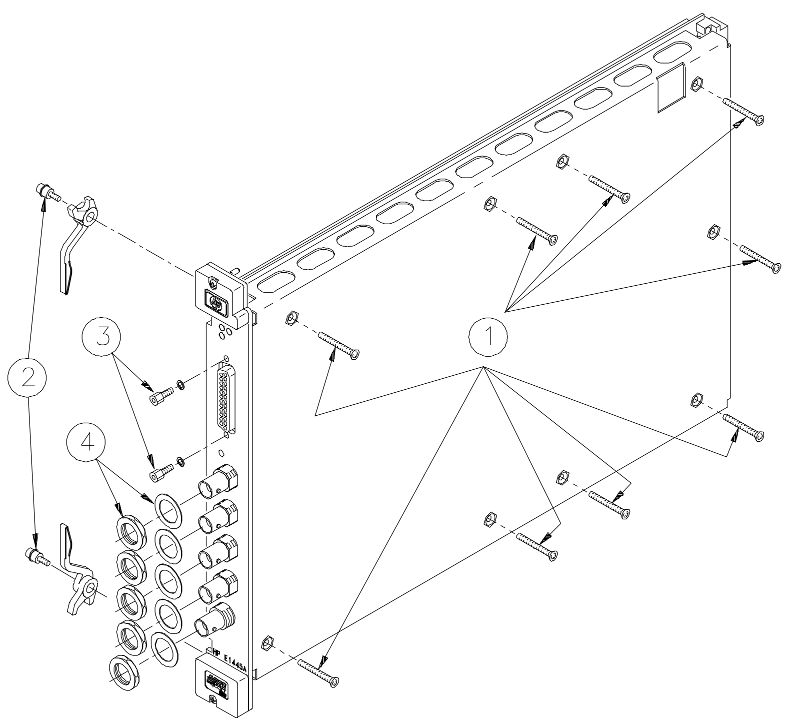

Figure 5-1. E1445A Disassembly

Removing BNC Connectors

Use the following steps to remove the AFG front panel BNC connectors (refer to Figure 5-2):

1. Unsolder wires
2. Remove the two T8 torx screws
3. Remove the BNC connector
4. Reverse the order to reinstall the connector

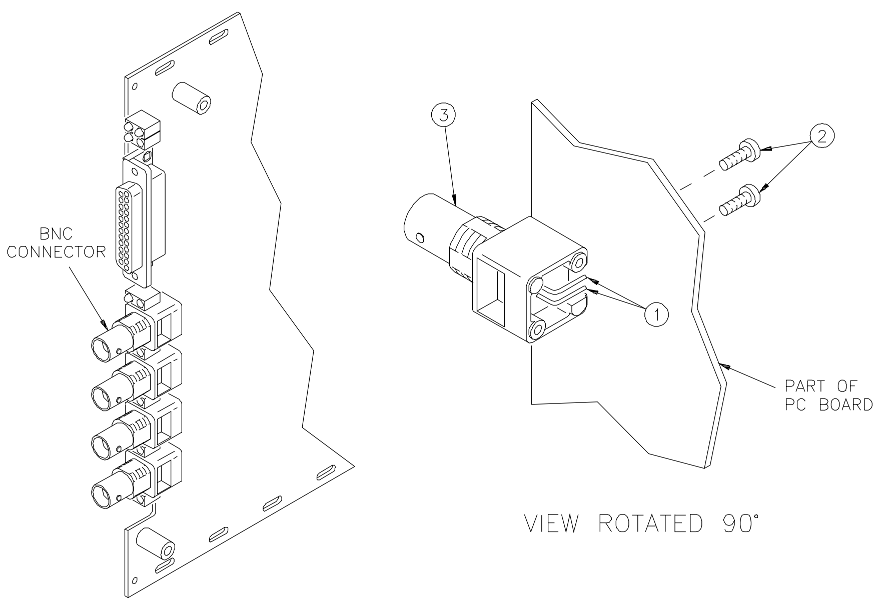

Figure 5-2. Removal of BNC Connectors

Repair/ Maintenance Guidelines

This section provides guidelines for repairing and maintaining the Agilent E1445A AFG, including:

- ESD precautions
- Soldering printed circuit boards
- Post-repair safety checks

ESD Precautions

Electrostatic discharge (ESD) may damage static sensitive devices in the Agilent E1445A AFG. This damage can range from slight parameter degradation to catastrophic failure. When handling AFG assemblies, follow these guidelines to avoid damaging AFG components:

- Always use a static-free work station with a pad of conductive rubber or similar material when handling AFG components.

- If a device requires soldering, be sure the assembly is placed on a pad of conductive material. Also, be sure that you, the pad, and the soldering iron tip are grounded to the assembly.

Soldering Printed Circuit Boards

When soldering to any circuit board, keep in mind the following guidelines:

- Avoid unnecessary component unsoldering and soldering. Excessive replacement can result in damage to the circuit board and/or adjacent components.

- Do not use a high power soldering iron on etched circuit boards, as excessive heat may lift a conductor or damage the board.

- Use a suction device or wooden toothpick to remove solder from component mounting holes. When using a suction device, be sure that the equipment is properly grounded.

Post-Repair Safety Checks

After making repairs to the Agilent E1445A AFG, inspect the AFG for any signs of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing. Determine and correct the cause of the condition. Then perform the Self-Test described in Chapter 2 to verify that the AFG is functional.

Agilent Technologies

E1445-90011