Contents

HP E1418A 8/16-Channel D/A Converter Service Manual

Edition 1

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Certification

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

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HEWLETT® PACKARD

HP E1418A 8/16 Channel D/A Converter Module Service Manual
Edition 1

Documentation History

All Editions and Updates of this manual and their creation date are listed below. The first Edition 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 or add additional information to the current Edition of the manual. Whenever a new Edition is created, it will contain all of the Update information for the previous Edition. Each new Edition or Update also includes a revised copy of this documentation history page.

Edition 1 . . . . August 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. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

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

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

For continued protection against fire, replace the line fuse(s) only with fuse(s) of the same voltage and current rating and type.
DO NOT use repaired fuses or short-circuited 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 a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

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

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

Declaration of Conformity

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Company
Loveland Manufacturing Center

Manufacturer's Address: 815 14th Street S.W.
Loveland, Colorado 80537

declares, that the product:

Product Name: 16 Channel 16 Bit D/A Converter

Model Number(s): HP E1418A

Product Options: All

conforms to the following Product Specifications:

Safety: IEC 1010-1 (1990) Incl. Amend 1 (1992)/EN61010-1 (1993)
CSA C22.2 #1010.1 (1992)
UL 3111

EMC: CISPR 11:1990/EN55011 (1991): Group1 Class A
IEC 801-2:1991/EN50082-1 (1992): 4kVCD, 8kVAD
IEC 801-3:1984/EN50082-1 (1992): 3 V/m
IEC 801-4:1988/EN50082-1 (1992): 1kV Power Line, 0.5kV Signal Lines

Supplementary Information: The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (inclusive 93/68/EEC) and carries the "CE" marking accordingly.

Tested in a typical configuration in an HP C-size VXI mainframe.

November 6, 1995 **Jim White, QA Manager**

European contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department HQ-TRE, Herrenberger Straße 130, D-71034 Böblingen, Germany (FAX +49-7031-14-3143).

Notes

Chapter 1
General Information

Introduction

This manual contains information required to test, troubleshoot, and repair the HP E1418A 8/16 Channel D/A Converter Module. See the *HP E1418A User's Manual* for additional module information. Figure 1-1 shows the HP E1418A module.

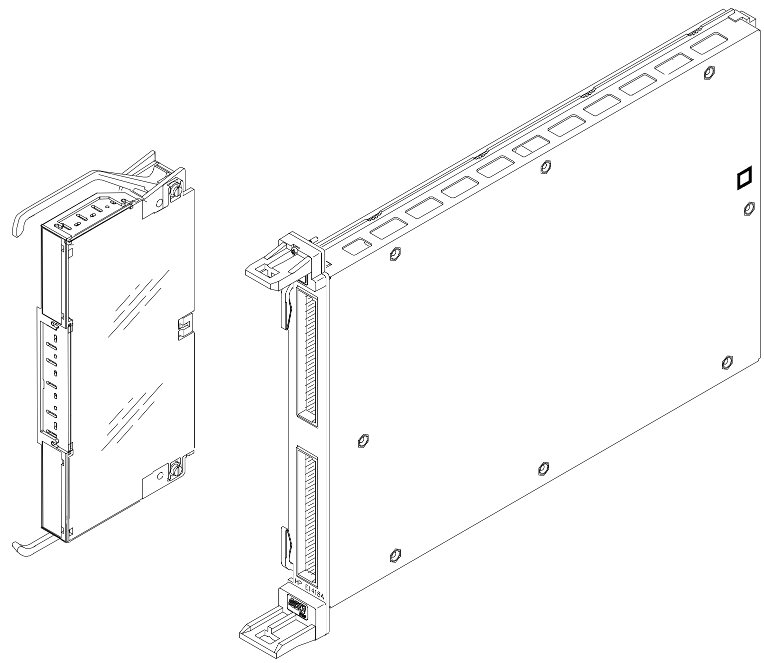


Figure 1-1. HP E1418A D/A Converter Module

Safety Considerations

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

Refer to the WARNINGS page (page 6) in this manual for a summary of safety information. Safety information for preventive maintenance, testing, adjusting, 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.

SHOCK HAZARD. Only service-trained personnel who are aware of the hazards involved should install, remove, or configure the module. Before you remove any installed module, disconnect AC power from the mainframe and from other modules that may be connected to the module.

CHANNEL WIRING INSULATION. All channels that have a common connection must be insulated so that the user is protected from electrical shock. This means wiring for all channels must be insulated as though each channel carries the voltage of the highest voltage channel.

CAUTION

MAXIMUM VOLTAGE. The maximum voltage that can be applied to any channel is 42 V Peak/42 Vdc. The maximum voltage from any channel to ground is 42 V Peak/42 Vdc.

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

PARTS REMOVAL. This module uses a surface mount printed circuit assembly. Special soldering equipment is required for parts removal or replacement. Use of standard soldering equipment will cause damage to the printed circuit board and is not covered under warranty.

Module Description

The HP E1418A is an 8 or 16 channel digital-to-analog converter module for use in a VXIbus C-size mainframe. The module is a register based device. The module can be programmed via direct register access or, with the appropriate driver, by high level commands. This manual describes programming the module using SCPI (Standard Commands for Programmable Instruments) and the SCPI driver.

Each HP E1418A module is a unique instrument having its own output buffer and error queue. Multiple modules can not be combined into a single instrument.

Each channel can be configured to either voltage or current output mode. When configured for voltage output, voltages in the range of -16.0 V to +16.0 V can be set. When configured for current output, current in the range of -0.02 to + 0.02 Amps can be set. The channel output mode can be programmatically set, or, can be forced to either voltage or current by mechanical jumpers on the terminal block.

Each output channel is individually configurable to be either an isolated output or a non-isolated output. Channel configuration to isolated or non-isolated is made by individual plug-on modules for each channel.

Module Specifications

Specifications are listed in Appendix A of this manual and in the *HP E1418A User's Manual*. These specifications are the performance standards or limits against which the module may be tested.

Module Serial Numbers

Devices covered by this manual are identified by a serial number prefix listed on the title page. Hewlett-Packard uses a two-part serial number in the form USXXXXYYYYY, where US is the country of origin, XXXX is the serial prefix, and YYYYY is the serial suffix. The serial number prefix identifies a series of identical instruments. The serial number suffix is assigned sequentially to each instrument. The serial number plate is located on the right-hand shield near the backplane connectors.

Ordering Options

The module may be ordered from Hewlett-Packard in a variety of configurations. As ordered, the module may have the following options:

	Description
HP E1418A	8-Channel D/A Converter with Non-Isolated Outputs
HP E1418A Option 001	16-Channel D/A Converter with Non-Isolated Outputs
HP E1418A Option 002	8-Channel D/A Converter with Isolated Outputs
HP E1418A Option 003	16-Channel D/A Converter with Isolated Outputs

Field Kits

The module can also be user configured. The following field expansion and configuration kits are available. Each field kit contains installation instructions.

	Description	Use
HP E1523A	Single Channel Isolated plug-on module	To change a single channel from non-isolated to isolated output.
HP E1524A	Expansion kit, 8-Channel Non-Isolated Outputs	To add 8 additional non-isolated channels to an existing 8-channel module.
HP E1525A	Expansion kit, 8-Channel Isolated Outputs	To add 8 additional isolated channels to an existing 8-channel module.

Terminal Modules

The standard HP E1418A Terminal Module provides screw terminals for connections. Two other terminal options are available with the HP E1418A:

- Crimp and Insert (Option A3E)
- Ribbon Cable (Option A3H)

Recommended Test Equipment

Table 1-1 lists the test equipment recommended for testing and servicing the module. 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, HP-IB	HP-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	F,O,P,T
Mainframe	Compatible with the HP E1418A	E1400B/T, E1401A/T, or E1401B	F,O,P,T
Command Module, VXILink, EPC7 Embedded Controller	Compatible with Module Resource manager in Slot 0 Logical address 0 Typical HP-IB address 9 Requires the downloaded driver "E1418"	E1405B or E1406A/B	F,O,P,T
Digital Multimeter 5 1/2 or 6 1/2 digit	Voltage measurements to ± 16.8 Vdc Current measurements to ± 0.02 A Four-wire resistance measurements from 50 Ω to 500 Ω	HP 3458A or HP 34401A	O, P, T
Terminal Module	Compatible with the HP E1418A	HP E1418-60101	O, P,T
Resistor	10 kΩ , 1%, 0.25 W, metal film	Any available supplier meeting the requirements	P
Resistor	600 Ω , 1%, 0.25 W, metal film		P
User's Manual		E1418-90001	F,O,P,T

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

Chapter 2
Installation

Introduction

This chapter contains the following topics:

- Initial Inspection
- Preparation for Use
- Environment
- Shipping Guidelines

Initial Inspection

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, keep the container until the shipment contents have been checked and the module has been checked mechanically and electrically. Chapter 4 of this manual gives procedures to check the electrical performance.

WARNING

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

If the contents are incomplete, if there is mechanical damage or defect, or if the module does not pass the electrical performance tests, notify your nearest Hewlett-Packard Sales and Service Office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as Hewlett-Packard. Keep the shipping materials for the carrier's inspection.

Preparation for Use

Chapter 1 of the *HP E1418A User's Manual* contains complete instructions for installing the module in a mainframe and installing a terminal module.

Refer to the mainframe user's manual, command module user's manual, and the *Installing Device Drivers* installation note to prepare the mainframe.

Prepare the Module

Verify or set the module's logical address. Refer to the *HP E1418A User's Manual* for instructions. In this manual the factory default logical address of 72 is used.

To prepare the module for the adjustment procedures in Chapter 5, set or verify the position of the CAL Secure Enable Jumper before installing the module in the mainframe. (The jumper is factory set to CAL.) Figure 5-2 on page 62 shows this jumper.

Prepare the Terminal Module

The procedures in this manual show the screw-type terminal module. To prepare this terminal module, you will need to set the jumpers and make connections. If you are using other types of terminal modules, consult the *HP E1418A User's Manual* for proper connections.

Terminal Module Jumpers

The screw-type terminal module contains jumpers that control how the HP E1418A operates. To prepare the module for the Verification Tests in Chapter 4 and Adjustments in Chapter 5, the terminal module jumpers must be set to allow the module to be programmed from the backplane. The HP E1418A will operate without any jumpers installed. Figure 2-1 shows the jumper locations and example settings.

There are two jumpers for each channel; a P/J jumper and a V/I jumper. The two jumpers work together.

The **P/J jumper** sets the channel output mode to be either Program Selectable or Jumper Selectable. When the jumper is in the program selectable position, the channel output mode can be set via programming commands. The program selectable position is recommended for the Verification Tests and Adjustment procedures in this manual. In the jumper selectable position, the channel output mode is set via the V/I jumper.

The **V/I jumper** sets the channel output mode to either voltage or current when the P/J jumper is set to the Jumper Selectable position. When the P/J jumper is set to Program Selectable, this jumper has no effect.

Note — With no jumpers installed, the module will be in the Program Selectable output mode.

- If you are using a terminal module dedicated to testing the HP E1418A, you can remove all the jumpers or put the jumpers in the storage position.
- If you are using the end-user's terminal module, record the positions of the jumpers. Set the P/J jumpers to the programmable position. Before returning the module to use, restore the P/J jumpers to their original position.

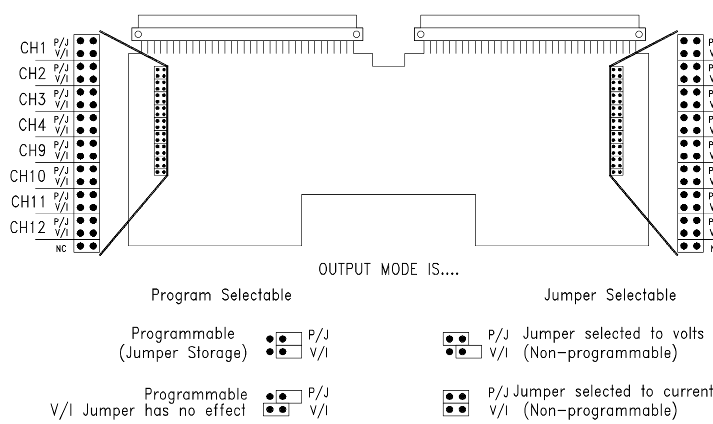


Figure 2-1. P/J and V/I Jumpers

Terminal Module Connections

The Verification Tests require four-wire connections at each channel. The Adjustment procedures can be performed using a single connections at the CAL terminals. Additional connection information is given in the procedures in Chapters 4 and 5 of this manual.

Prepare the Command Module

All verification and adjustment procedures in this manual use SCPI (Standard Commands for Programmable Instruments). Prepare the command module by downloading the SCPI driver named "E1418". Downloading instructions are given in the *Installing Device Drivers* installation note.

Environment

The recommended operating altitude for the module is 2000 m (6000 ft) or less. The recommended operating environment for the module is:

Environment	Temperature	Humidity
Operating	0 ^{o}C to + 55 ^{o}C	<65% relative (0 ^{o}C to + 40 ^{o}C) non condensing
Storage and Shipment	– 40 ^{o}C to + 75 ^{o}C	<65% relative (0 ^{o}C to + 40 ^{o}C) non condensing

Shipping Guidelines

If you need to return the HP E1418A to Hewlett-Packard, first remove any terminal modules before packaging for shipment. Attach a tag to the module identifying the owner and indicating the service or repair required. Mark the shipping container “FRAGILE”. If you are exchanging a module, read Assembly Exchange beginning on page 85.

In any correspondence, refer to the module by model number and full serial number.

Hewlett-Packard recommends using shipping containers and materials identical to those used by the factory. These materials are available through Hewlett-Packard Sales and Service Offices.

If you use commercially available shipping materials, place the module in an anti-static bag and wrap the module in heavy paper or plastic. Use a strong shipping container. A double wall carton of 2400 Pa (350 psi) test material is adequate.

Use enough shock-absorbing material (layer at least 75 mm to 110 mm, 3 in to 4 in) around the module to provide firm cushion and to prevent movement in the container. Protect the front panel with cardboard. Seal the container securely and mark the container “FRAGILE”.

Chapter 3
Operating Information

Introduction

This chapter provides operating information, preventive maintenance instructions, and operators checks.

Operation

The *HP E1418A User's Guide* is your reference for module operation. The User's Guide contains information about module setup, application examples, and a complete SCPI command reference.

Querying Module Identification and Configuration

This example will query the module for the identification string and determine the module configuration.

The module identification is obtained using the IEEE-488 Command Command ***IDN?**.

/* *Send query to the module**/
*IDN?
/* *Enter a string**/

The string returned will be similar to one of the following:

HEWLETT-PACKARD,E1418A_8CH,xxxxxxxxxx,A.01.00
or
HEWLETT-PACKARD,E1418A_16CH,xxxxxxxxxx,A.01.00

The xxxxxxxxxx portion of the response string is the module serial number.

The number of channels in the module (8 or 16) is indicated by the **E1418A_8CH** or **E1418A_16CH** portion of the returned string.

The module configuration is obtained using the **DIAGnostic:CONFiguration?** query.

/* *Send query to the module*/
DIAG:CONF?
/* *Enter six integers and decode the integers*/*

The **DIAG:CONF?** query returns six integers. The six integers returned contain the module configuration and have the following meaning.

Integer Returned	Meaning
1st	Expansion Board ID in the form: 0 = present, 7 = none (expansion board contains channels 9 through 16)
2nd	Terminal Module ID in the form 0 = screw type, 7 = none or other
3rd	Isolated/Non-isolated Channel status A bit set to 0 indicates an isolated channel A bit set to 1 indicates a non-isolated channel or no plug-on module installed (DO NOT operate the module without a plug-on module) Bits 0 – 15 correspond to channels 1 – 16, respectively*
4th	Channel Mode A bit set to 0 indicates a current output channel A bit set to 1 indicates a voltage output channel Bits 0 – 15 correspond to channels 1 – 16, respectively*
5th	Channel Output State A bit set to 0 indicates the channel output relay is closed A bit set to 1 indicates the channel output relay is open Bits 0 – 15 correspond to channels 1 – 16, respectively*
6th	Channel Mode Programmable State (P/J Jumper) A bit set to 0 indicates a channel is not mode programmable A bit set to 1 indicates a channel is mode programmable Bits 0 – 15 correspond to channels 1 – 16, respectively*

* For 8-channel configurations, the upper 8 bits of integers 3, 4, 5, and 6 are set to 1's.

For example, if the following six integers are returned, the module has the configuration indicated.

Integer	Decimal Value	Configuration
1st	7	No expansion board installed (Only channels 1 through 8)
2nd	7	No Terminal Module installed or unknown terminal module installed
3rd	-1	All channels are non-isolated
4th	-1	All channels are voltage output channels
5th	-1	All channel outputs are disabled (all output relays are open)
6th	-1	All channels are output mode programmable

Configuration Example

The following program segment demonstrates how to read the module identification string and the configuration. The configuration integers are bit manipulated using the C operator for bit shifting

result = result <<1

(a one bit shift to the left). The code shown in this example can be obtained from the file prftest.c on the examples disk provided with this manual.

```
/**  FUNCTION PROTOTYPES  **/
void main (void);
void err_handler(ViSession vi, ViStatus x);    /* VTL error routine                    */
void sys_err(ViSession resource);              /* Checks for SCPI programming errors   */

/** GLOBAL **/
ViStatus err;
ViSession defaultRM, cmd, dac, dmm;
int num_chan;

void main (void)
{
        int i,result = {0},config [6]={0},num_chan = {0};

        err=viPrintf(dac, "DIAG:CONF?\n");        /* request module configuration */
        if(err  VI_SUCCESS) err_handler(dac, err);
        err=viScanf(dac, "%,6d", &config);         /* returns six integers          */
        if(err  VI_SUCCESS) err_handler(dac, err);
        sys_err (dac);      /*  SCPI error check    */
```

```
/* First integer */
result=config[0];    /*  Expansion board     */
if (result == 0)
{
        printf ("Module is a 16 channel device\n");
        num_chan = 16;
}
else
{
        if (result == 7)
        {
                printf ("Module is an 8 channel device\n");
                num_chan=8;
        }
        else
        {
                printf ("Error in DIAG:CONF ? command\n");
                printf ("First value returned was %d \n",config[0]);
                printf ("Program will terminate\n");
                pause();
                abort;
        }
}

/* Second integer */
result = config [1];      /*  Terminal Module   */
if (result == 0)
{
        printf ("Module has a screw type terminal module installed\n");
}
else
{
        if (result == 7)
        {
                printf ("Module does NOT have a terminal module installed\n");
        }
        else
        {
                printf ("Error in DIAG:CONF ? command\n");
                printf ("First value returned was %d \n",config[0]);
                printf ("Program will terminate\n");
                pause();
                abort;
        }
}
```

```
/* Third integer */
result=config[2];       /* Isolated or non-isolated outputs  */
if (num_chan == 8) result = result << 8; /* strip upper 8 bits */
for (i=num_chan;i>0;i—)
{
        if (result > = 0x8000)
        {
                printf (“Channel %d is configured for non-isolated  output\n”,i);
        }
        else
        {
                printf(“Channel %d is configured for isolated output\n”,i);
        }
        result = result << 1;
}

/* Fourth integer */
result=config[3];      /*  Output Mode Voltage or Current  */
if (num_chan == 8) result = result << 8; /* strip upper 8 bits */
for (i=num_chan;i>0;i—)
{
        if (result > = 0x8000)
        {
                printf (“Channel %d is set to voltage output mode\n”,i);
        }
        else
        {
                printf(“Channel %d is set to current output mode\n”,i);
        }
        result = result << 1;
}
```

```
        /* Fifth integer */
        result=config[4];      /*  Channel output ON or OFF   */
        if (num_chan == 8) result = result << 8; /* strip upper 8 bits */
        for (i=num_chan;i>0;i—)
        {
                if (result > = 0x8000)
                {
                        printf (“Channel %d output is disabled\n”,i);
                }
                else
                {
                        printf(“Channel %d output is enabled\n”,i);
                }
                result = result << 1;
        }

        /* Sixth integer */
        result=config[5];      /*  Program or Jumper Selectable channels   */
        if (num_chan == 8) result = result << 8; /* strip upper 8 bits */
        for (i=num_chan;i>0;i—)
        {
                if (result >= 0x8000)
                {
                        printf (“Channel %d output mode is programmable\n”,i);
                }
                else
                {
                        printf(“Channel %d output mode is fixed and jumper selected\n”,i);
                }
                result = result << 1;
        }
                                •
                                •
                                •
}
```

Preventive Maintenance

Preventive maintenance consists of periodically cleaning the front panel, the terminal module, and performing the Operator's Check. Clean the module and terminal module yearly, or more often if the module is used in very dusty or humid areas. Disassembly of the module is not recommended for cleaning. However, if the module is disassembled for repair or reconfiguration, the printed circuit board assemblies (PCAs) can be blown off with a properly grounded airgun. Remove the terminal module cover to blow dust off the terminal printed circuit board and case. Table 3-1 shows the recommended cleaning equipment and supplies.

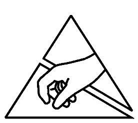
Table 3-1. Recommended Cleaning Equipment and Supplies

Description	Recommended Use
Mild Soap Solution	Clean face plate panel and terminal covers.
Lint-free Cloth	Clean face plate panel and terminal covers.
Airgun with grounded nozzle	Remove dust from the printed circuit boards and terminal case.

WARNING

To eliminate possible electrical shock, disconnect ac power from the mainframe and disconnect all outputs to the terminal module before removing the module from the mainframe.

CAUTION



The printed circuit assemblies (PCAs) contain static-sensitive devices that can be damaged by careless handling. Use static-control devices (wrist straps, mats, and tools) when handling the module. Chapter 6 contains additional precautions for electrostatic discharge (ESD).

Cleaning Procedure

Use the following procedure to clean the HP E1418A.

Terminal Module

1. Remove the terminal module from the main module.
2. Disconnect all external wiring.
3. Clean the terminal module covers with a mild soap solution and lint-free cloth.
4. Remove the terminal module cover and blow any dust or debris from the case.
5. Reassemble the terminal module.
6. Reconnect the external wiring.

Main Module

1. Remove the terminal module from the main module.
2. Clean the main module face plate with a mild soap solution and lint-free cloth.

Note

Disassembling the module exposes the assemblies to ESD damage and is usually unnecessary. Perform steps 3 through 5 only if the module is disassembled for repairs or reconfiguration.

---

3. Disassemble the module following the instructions in Chapter 6.
4. Using an airgun with a grounded nozzle, remove dust from the PCA assemblies.
5. Reassemble the module.

Operator's Checks

The operator's check for the HP E1418A has two parts.

The first part consists of sending the **SYStem:ERRor?** query to the module following power-on and entering the response. This check should be performed after every power-on sequence. At power-on, the HP E1418A performs a brief self-test that ensures the module can communicate with the backplane. A successful self-test returns an integer and a string:

+0,"No Error"

Any other response indicates a failure in the module. Chapter 6 contains troubleshooting information.

Once the power-on self-test has been checked, the operator may perform a full self-test by sending the ***TST?** query and entering the response. This query executes a full self-test that checks all circuits of the module except the output relays. A successful self-test returns:

+0

Any other response indicates a failure. Chapter 6 contains additional information about the self-test error codes and troubleshooting information.

Operator Check Example

This example checks the module for errors after power-on and then performs a full self-test.

```
/**  FUNCTION PROTOTYPES  **/
void main (void);
void err_handler(ViSession vi, ViStatus x);       /* VTL error routine */
void sys_err(ViSession resource);                 /* SCPI error routine */
```

•

•

•

```
ViStatus err;                                     /* Global VTL error variable */
void main (void)
{
        int selftest;
        char selftestresults [80];
        err=viPrintf(dac, "*TST?\n");                  /* run self test */
        if(err  VI_SUCCESS) err_handler(dac, err);
        err=viScanf(dac, "%d%t", &selftest,&selftestresults);       /* enter integer and string returned */
```

```
        if(err  VI_SUCCESS) err_handler(dac, err);
        if (selftest != ’0’)
        {
                printf (“Self Test failed\n”);
                printf (“The first error encountered was\n”);
                printf (“Error number %d %s\n”,selftest,selftestresults);
                printf (“This program will terminate\n”);
                pause();
                abort;
        }
        else
        {
                printf (“Self Test PASSED”);
        }
}

/*** VTL Error handling function ***/
void err_handler (ViSession dac, ViStatus err)
{
        char buf[1024]={0};
        viStatusDesc(dac,err,buf);
        printf(“VTL ERROR = %s\n”, buf);
        return;
}  /*End of VTL error handler */

/*** SCPI error checking and reporting function ***/
void sys_err(ViSession resource)  /* Test for SCPI Errors */
{
        char buf [1024] = {0};
        int err_no;
        err = viPrintf (resource, “SYST:ERR?\n”); /* Check for an error */
        if (err < VI_SUCCESS) err_handler(resource,err);   /* Check VTL errors */
        err = viScanf (resource,"%d%t",&err_no,&buf);
        if (err < VI_SUCCESS) err_handler(resource,err);  /* Check VTL errors */
        while (err_no != 0) /* Report all errors in error que */
        {
                printf (“\nCommand Error: %d,%s\n”,err_no,buf);
                err = viPrintf (resource, “SYST:ERR?\n”);
                if (err < VI_SUCCESS) err_handler(resource,err);  /* Check VTL errors */
                err = viScanf (resource,"%d%t",&err_no,&buf);
                if (err < VI_SUCCESS) err_handler(resource,err);  /* Check VTL errors */
        }
        flushall();     /* Clean out the buffers */
        err = viFlush(resource,VI_READ_BUF);
        if (err < VI_SUCCESS) err_handler (resource,err);   /* Check VTL errors */
        err = viFlush(resource,VI_WRITE_BUF);
        if (err < VI_SUCCESS) err_handler (resource,err);  /* Check VTL errors */
} /* End of checking for SCPI errors */
```

Chapter 4
Verification Tests

Introduction

Three test procedures are given in this chapter. These test procedures are used to verify that:

- the HP E1418A is functional (Functional Verification)
- the HP E1418A meets selected testable specifications (Quick Verification)
- the HP E1418A 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 of this manual.

Test Conditions

Table 1-1, on page 14, lists the recommended test equipment. When performing the test procedures, observe the following test conditions:

- The ambient temperature should be between 18 °C and 28 °C. The temperature should be stable within ± 1 °C.
- The relative humidity should be < 65%, non-condensing.
- Install the module, apply power, and allow the module to warm up for at least 15 minutes.

Hewlett-Packard recommends performance tests be performed at one year intervals. In severe operating environments, or after heavy use, perform the tests more often.

About the Verification Tests

Three levels of verification tests are described in this chapter:

- Functional Verification Tests
- Quick Verification Tests
- Performance Verification Tests

You should perform the Functional Verification test before either the Quick Verification or full Performance Verification tests.

Functional Verification Test

The Functional Verification test provides a high confidence that the module is operational. A brief self-test is performed when power is first applied to the module. This test assures that module can communicate with the mainframe.

The Functional Verification Test performs a more complete self-test using the SCPI common command *TST?. If this test passes, you have a high confidence level (90%) that the module is operational.

If the module fails the Functional Verification Test, repair is needed.

Quick Verification Tests

The Quick Verification Test combines a Functional Verification Test with an abbreviated set of Performance Tests to give a high confidence level that the module is operational and meets its specifications. The Quick Performance Test is the minimum set of tests recommended after any service activity.

These tests check the module's performance for normal accuracy and drift mechanisms. These tests do not check for abnormal component failures.

Quick Verification Tests are designated with the letter "Q" in the Performance Verification Tests. To perform the Quick Verification Tests:

1. Perform a Functional Verification Test.
2. Perform the Performance Verification Tests designated by the letter "Q" in the table beginning on page 46.

If the module fails the Quick Verification Test, adjustment or repair is needed.

Performance Verification Tests

Performance Verification Tests give a high confidence that the module is operational and meets its specifications. The Performance Verification Tests can be used as acceptance tests when the module is first received.

The Performance Verification Tests should be run at the calibration interval (Hewlett-Packard recommends a one year interval). Run the tests to characterize the module against the specifications. Run the Performance Verification Tests after any adjustment to verify the adjustment.

If the module fails any Performance Verification Tests, adjustment or repair is needed.

Performance Test Record

Table 4-1, beginning on page 46, provides space to enter the results of each Performance Verification test. The table also lists the upper and lower test limits.

About Program Examples

In this manual test procedures are shown with a portion of an example program that performs the test. These examples are in ANSI C format and complete program files are included on the disk supplied with this manual. Most examples in this chapter are included. The examples are ASCII files with the *.c extension.

Note

The **int** data type is system dependent. These examples were developed on a system where **int** is a 16-bit integer. Other systems may define **int** to be a different width.

In the examples, the Hewlett-Packard VISA Transition Library is used for I/O operations with the VXIbus. A Hewlett-Packard command module (HP E1405/E1406) is used and controlled via HP-IB.

To use the Hewlett-Packard VISA Transition Library (abbreviated as VTL), include the visa.h header file.

```
#include visa.h
```

Hewlett-Packard VTL function calls and data types typically begin with the lower case letters **vi**. Output and enter are performed with functions named **viPrintf** and **viScanf**. Both these functions require a session (a VTL defined I/O function) to uniquely identify the device being controlled. In the examples, the session has been named **dac**.

SCPI drivers

In this manual, all programming examples and procedures assume the use of the SCPI driver and HP E1406A Command Module. The HP E1418A module is shipped with two 3.5" disks. These disks contain the SCPI driver for the HP E1406A Command Module. One disk is in LIF format and one disk is in DOS format. *Installing Device Drivers Installation Note* is included with the disks. Follow the instructions contained in the installation note to properly install the device driver.

Use the **DIAG:DRIV:LIST?** query on the command module to verify that the correct device driver is installed. Responses to this query vary depending upon the drivers loaded on your system. A typical response contains a list of all drivers installed and might look like:

```
E1418,E1418,A.01.00,RAM;SWITCH,SWITCHBOX,A.08.00,RAM
;
SYSTEM,E1405A,A.08.00,ROM;IBASIC,IBASIC,A.04.02,ROM;
VOLTMTR,E1326A,A.05.00,ROM;SWITCH,SWITCHBOX,A.07.00,
ROM;COUNTER,E1332A,A.04.02,ROM;COUNTER,E1333A,A.04.0
2,ROM;
DIG_I/O,E1330A,A.04.03,ROM;D/A,E1328A,A.04.02,ROM
```

The string `E1418,E1418,A.01.00`, should be located somewhere within the returned string.

SCPI Command Reference

The SCPI (Standard Commands for Programmable Instruments) commands are not documented in this manual except in a general manner. Complete SCPI commands, including syntax and parameters, applicable to the module are documented in the *HP E1418A User's Guide*.

Functional Verification Test

The Functional Verification Test quickly verifies that the module is operational. Perform this test any time to verify or check the operation. Perform this test before beginning any Quick Verification or Performance Verification Tests.

Functional Verification Test Procedure

Use the following procedure to verify the module's operation.

1. Install the module in the mainframe and apply power.
2. Verify the module passed its power-on self-test by executing the **SYStem:ERRor?** query and entering the results.

   A passed self-test is indicated by the return
   +0, "No Error"
   any other return value indicates a power-on failure.

Note

If an incorrect module address is used, the module will not respond. Verify the module's address before troubleshooting.

---

3. Execute the full self-test by sending the ***TST?** query and entering the result.

   A passed self-test is indicated by the return
   +0
   Any other return value indicates a failure. Additional information about the self-test results and self-test error codes is given in Chapter 6 beginning on page 73.

Functional Verification Test Example

An example of the Functional Verification Test is shown beginning on page 27.

Performance Verification Tests

These procedures test the electrical performance of the HP E1418A using the specification in Appendix A as the performance standards. These tests are suitable for incoming inspections, troubleshooting, and preventive measures.

DC Voltage Output Verification

This procedure tests the dc voltage output performance of the module.

1. For each channel in the module, connect the 10 kΩ resistor and DMM as shown in Figure 4-1. Channel 1 connections are shown in the figure. Connect the other channels in a similar manner. Set the DMM to measure dc volts.

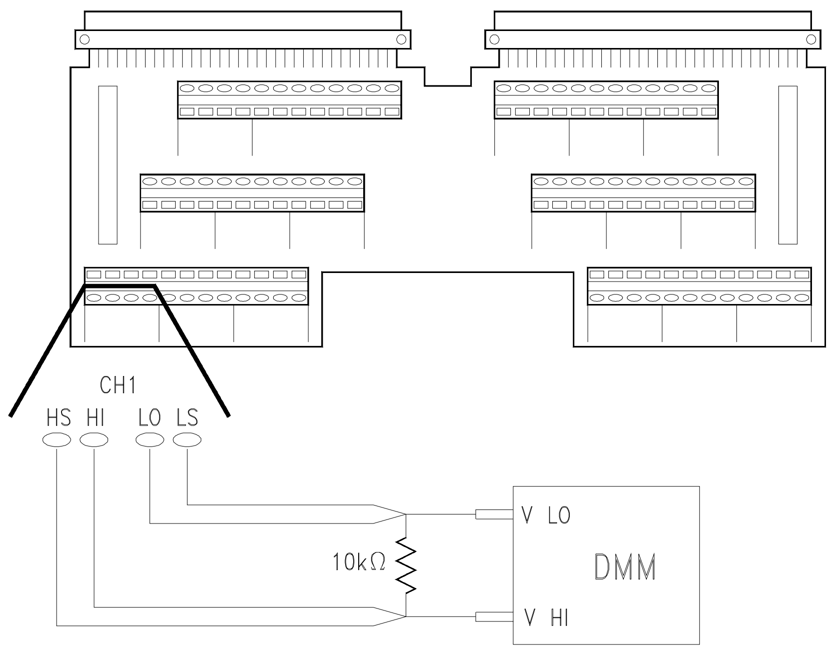


Figure 4-1. DC Voltage Output Connections (Channel 1)

2. Set the channel to output each of the following voltages:

+16.00	– 4.00
+12.00	– 8.00
+ 8.00	–12.00
+ 4.00	–16.00
0.00	

   Use the **APPLY*n*:VOLTage xx.xx** command, where ***n*** is the channel number and **xx.xx** is the voltage to output.

3. For each voltage, measure the output voltage with the DMM, enter it in the table beginning on page 46, and compare the voltage output to the limits shown in the table.

4. Open the channel output relay by sending the **OUTPut*n* OFF** command, where ***n*** is the channel number.
5. Change the connections to the next channel and repeat steps 2, 3, and 4.
6. Repeat steps 2, 3, 4, and 5 for each channel.

DC Voltage Compliance Current

This test checks the compliance current in dc voltage.

1. For each channel in the module, connect the 600 Ω resistor and the DMM as shown in Figure 4-2. Channel 1 connections are shown in the figure. Connect the other channels in a similar manner. Set the DMM to measure dc voltage.

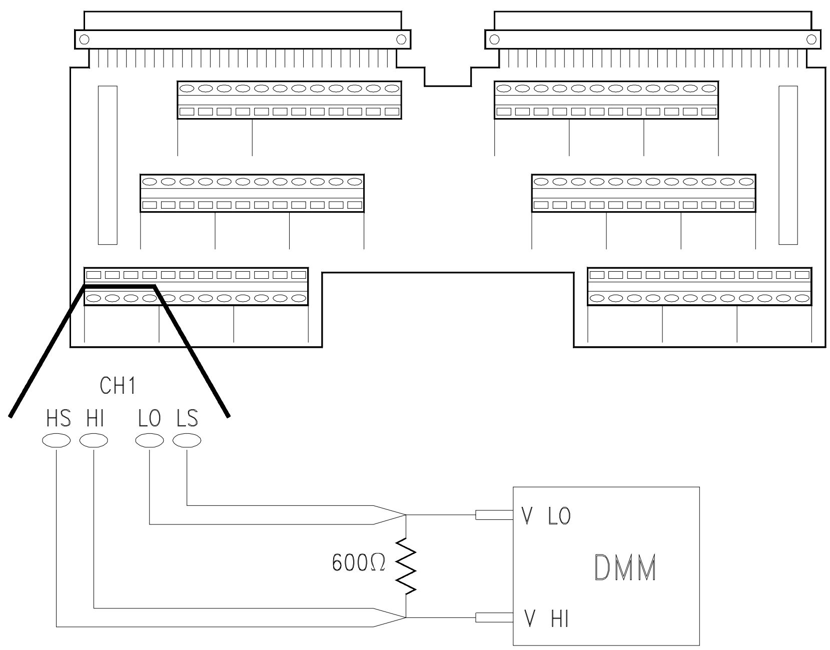


Figure 4-2. DC Voltage Output Connections (Channel 1)

2. Set the channel to output +12.00 V. Use the **APPLY*n*:VOLTage 12.00** command, where ***n*** is the channel number.
3. Measure the output voltage with the DMM, enter it in the table beginning on page 46, and compare the measured voltage to the limits shown in the table. The compliance current is inferred from the voltage across the resistor.
4. Open the channel output relay by sending the **OUTPut*n* OFF** command, where ***n*** is the channel number.
5. Change the connections to the next channel and repeat steps 2, 3, and 4.
6. Repeat steps 2, 3, 4, and 5 for each channel.

DC Voltage Short Circuit Output Current

This test checks the short circuit output current for each channel.

1. For each channel in the module, connect the DMM as shown in Figure 4-3. Channel 1 connections are shown in the figure. Connect the other channels in a similar manner. Set the DMM to measure dc current (the DMM should have a current shunt of 100 Ω or less for this test).

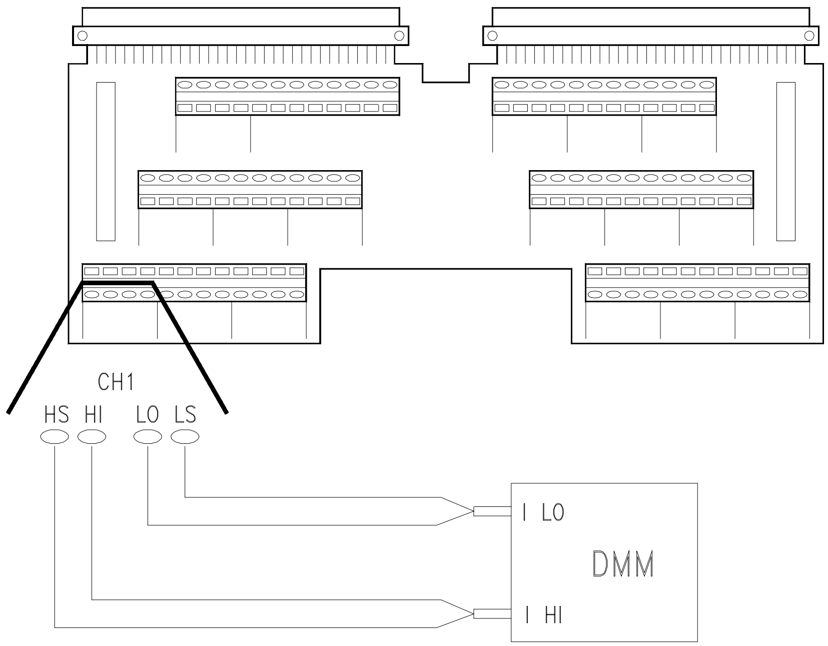


Figure 4-3. DC Voltage Output Connections (Channel 1)

2. Set the channel to output +16.00 V. Use the **APPLY*n*:VOLTage 16.00** command, where ***n*** is the channel number.
3. Measure the output current with the DMM, enter it in the table beginning on page 46, and compare the measured current to the limits shown in the table.
4. Open the channel output relay by sending the **OUTPut*n* OFF** command, where ***n*** is the channel number.
5. Change the connections to the next channel and repeat steps 2, 3, and 4.
6. Repeat steps 2, 3, 4, and 5 for each channel.

DC Current Verification

This test checks the dc current output performance of the module.

1. For each channel in the module, connect the DMM as shown in Figure 4-4. Channel 1 connections are shown in the figure. Connect the other channels in a similar manner. Set the DMM to measure dc current.

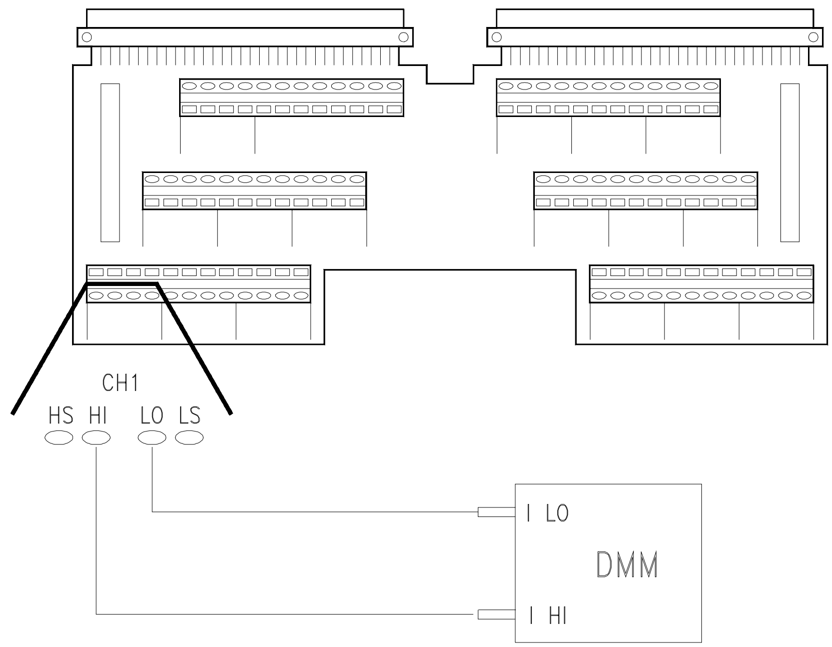


Figure 4-4. DC Current Output Connections (Channel 1)

2. Set the channel to output each of the following currents:

+0.020	–0.005
+0.015	–0.010
+0.010	–0.015
+0.005	–0.020
0.000	

   Use the **APPLy*n*:CURRent x.xxx** command, where ***n*** is the channel number and **x.xxx** is the current to output.

3. For each current, measure the output current with the DMM, enter it in the table beginning on page 46, and compare the current output to the limits shown in the table.
4. Open the channel output relay by sending the **OUTPut*n* OFF** command, where ***n*** is the channel number.
5. Change the connections to the next channel and repeat steps 2, 3, and 4.
6. Repeat steps 2, 3, 4, and 5 for each channel.

Performance Verification Tests Example

This example demonstrates a full performance verification test of the module. The code shown in this example can be obtained from the file **prftest.c** on the examples disk provided with this manual.

```
/**  FUNCTION PROTOTYPES  **/
void main (void);
void err_handler(ViSession vi, ViStatus x); /* VTL error routine */
void sys_err(ViSession resource);     /* Checks for SCPI programming errors */
void pause();                         /* Waits for a keystroke to continue program execution */
void dcv_check ();                    /* Voltage output verification test */
void compliance_check ();             /* Compliance current verification test */
void maxcurrent_check ();             /* Short circuit output current verification test */
void current_check ();                /* Current output verification test */
        /* DMM routines               */
void dmm_setup (char function [6], char range [6]); /* Set function and range for DMM */
float dmm_measure ();                 /* get the  dmm measurement */


/** GLOBAL **/
ViStatus err;
ViSession defaultRM, cmd, dac, dmm;
int num_chan;                         /* 8 or 16 */
float dcv_results [16][9]={0};        /* Voltage output verification test results */
float compliance_results [16] = {0};  /* Compliance current verification test results */
float maxcurrent_results [16] = {0};  /* Short circuit output current verification test results */
float current_results [16][9] = {0};  /* Current output verification test results */


void main (void)
{
        dcv_check ();
        compliance_check ();
        maxcurrent_check ();
        current_check ();
}
```

```
/*** Routine to perform the dcv performance test ***/
void dcv_check ()
{
        float v_out [9] = {16, 12, 8, 4, 0, -4,-8, -12, -16}; /* Voltages to output during test */
        int i,j,opc_check;
        char function [6] = {“VOLT:DC\0"},range [6] = {”100\0"};
        dmm_setup (function,range);
        printf (“Voltage Output Check on %d channels”,num_chan);
        printf (“\n\n”);
        printf (“DC VOLTAGE OUTPUT PERFORMANCE TEST\n\n”);
        for (i = 0;i != num_chan;i++)
        {
                /** connection instructions **/
                printf (“\tChannel %d test\n”,i+1);
                printf (“1.\tMake a four-wire connection from channel %d \n”,i+1);
                printf (“\tto a 10,000 Ohm resistor.\n”);
                printf (“2.\tMake a two-wire connection from the DMM to\n”);
                printf (“\tthe 10,000 Ohm resistor.\n”);
                printf (“3.\tThe DMM is set to make DC Volts Measurements on \n”);
                printf (“\tthe 100 V range.\n”);
                printf (“4.\tFor each channel in the HP E1418A,\n”);
                printf (“\t\tOutput 16 V, 12 V, 8 V, 4 V, 0 V, -4 V, -8 V, -12 V, -16 V.\n”);
                printf (“\t\tMeasure each voltage output on the DMM.\n”);
                printf (“\n\n”);
                pause();
                /** voltage output loop **/
                for (j=0;j<9;j++)
                {
                        err=viPrintf(dac, “APPLY%d:VOLTAGE %f;*OPC?\n”,i+1,v_out[j]); /* voltage output*/
                        if(err  VI_SUCCESS) err_handler(dac, err);
                        err=viScanf(dac, “%d”, &opc_check);  /* enter OPC integer  */
                        if(err  VI_SUCCESS) err_handler(dac, err);
                        dcv_results [i][j] = dmm_measure();
                }
                printf (“\nChannel %d Voltage Output Test Done\n\n”,i+1);
                err=viPrintf(dac, “OUTPUT%d OFF;*OPC?\n”,i+1); /* Turn output off     */
                if(err  VI_SUCCESS) err_handler(dac, err);
                err=viScanf(dac, “%d”, &opc_check);                     /* enter OPC integer  */
                if(err  VI_SUCCESS) err_handler(dac, err);
                sys_err (dac);      /* SCPI error check */
        }
        printf (“\n\nEnd of DC Voltage Output Test\n\n”);
        err=viPrintf(dac, “*RST\n”);
        if(err  VI_SUCCESS) err_handler(dac, err);
}
/*** End of dcv_check ***/
```

```
/*** Routine to perform the compliance current performance test ***/
void compliance_check ()
{
        float v_out = {12};           /* Voltage to output */
        int i,opc_check;
        char function [6] = {“VOLT:DC\0"},range [6] = {”100\0"};
        dmm_setup (function,range);
        printf (“\n\nCompliance Current Verification Test\n\n”);
        for (i = 0;i != num_chan;i++)
        {
                /** connection instructions **/
                printf (“\tChannel %d\n”,i+1);
                printf (“1.\tMake a four-wire connection from channel %d \n”,i+1);
                printf (“\tto a 600 Ohm resistor.\n”);
                printf (“2.\tMake a two-wire connection from the DMM to\n”);
                printf (“\tthe 600 Ohm resistor.\n”);
                printf (“3.\tThe DMM is set to make DC Volts Measurements on \n”);
                printf (“\tthe 100 V range.\n”);
                printf (“4.\tEach channel is set to output 12 V\n”);
                printf (“\t\tMeasure the voltage drop across the resistor output.\n”);
                printf (“\n\n”);
                pause();
                err=viPrintf(dac, “APPLY%d:VOLTAGE %f;*OPC?\n”,i+1,v_out); /* voltage output */
                if(err  VI_SUCCESS) err_handler(dac, err);
                err=viScanf(dac, “%d”, &opc_check);  /* enter OPC integer  */
                if(err  VI_SUCCESS) err_handler(dac, err);
                compliance_results [i] = dmm_measure();
                err=viPrintf(dac, “OUTPUT%d OFF;*OPC?\n”,i+1); /* Turn output off     */
                if(err  VI_SUCCESS) err_handler(dac, err);
                err=viScanf(dac, “%d”, &opc_check);                        /* enter OPC integer  */
                if(err  VI_SUCCESS) err_handler(dac, err);
                sys_err (dac);      /* SCPI error check */
        }
        printf (“\n\nend of Compliance Current Test\n\n”);
        err=viPrintf(dac, “*RST\n”);                    /* reset the dac            */
        if(err  VI_SUCCESS) err_handler(dac, err);
}
/*** End of compliance_check ***/
```

```
/*** Routine to perform the short circuit output current performance test ***/
void maxcurrent_check ()
{
	float v_out = {16};   /*voltage to output*/
	int i,opc_check;
	char function [6] = {“CURR:DC\0"},range [6] = {”0.100\0"};
	dmm_setup (function,range);
	printf (“\n\nShort Circuit Output Current Verification Test\n\n”);
	for (i = 0;i != num_chan;i++)
	{
		/** connection instructions **/
		printf (“\tChannel %d\n”,i+1);
		printf (“1.\tMake a four-wire connection from channel %d \n”,i+1);
		printf (“\tto the DMM current input terminals\n”);
		printf (“2.\tThe DMM is set to make DC current Measurements on \n”);
		printf (“\tthe 100 mA range.\n”);
		printf (“3.\tEach channel is set to output 16 V\n”);
		printf (“\t\tMeasure the current flowing through the DMM.\n”);
		printf (“\n\n”);
		pause();
		err=viPrintf(dac, “APPLY%d:VOLTAGE %f;*OPC?\n”,i+1,v_out); /* voltage output  */
		if(err  VI_SUCCESS) err_handler(dac, err);
		err=viScanf(dac, “%d”, &opc_check);                    /* enter OPC integer  */
		if(err  VI_SUCCESS) err_handler(dac, err);
		maxcurrent_results [i] = dmm_measure();
		err=viPrintf(dac, “OUTPUT%d OFF;*OPC?\n”,i+1); /* Turn output off     */
		if(err  VI_SUCCESS) err_handler(dac, err);
		err=viScanf(dac, “%d”, &opc_check);                    /* enter OPC integer  */
		if(err  VI_SUCCESS) err_handler(dac, err);
		sys_err (dac);      /* SCPI error check */
	}
	printf (“End of Short Circuit Output Current Test”);
	err=viPrintf(dac, “*RST\n”);
	if(err  VI_SUCCESS) err_handler(dac, err);
}
/*** End of maxcurrent_check ***/
```

```
/*** Routine to perform the current performance test ***/
void current_check ()
{
	float i_out [9] = {0.02F, 0.015F, 0.01F,0.005F, 0, -0.005F,-0.01F, -0.015F, -0.02F};
				/* Currents to output */
	int i,j,opc_check; */
	char function [6] = {"CURR:DC\0"},range [6] = {"0.100\0"};
	dmm_setup (function,range);
	printf ("\n\n");
	printf ("DC CURRENT OUTPUT PERFORMANCE TEST\n\n\n\n");
	for (i = 0;i != num_chan;i++)
	{
		/** connection instructions **/
		printf ("Channel %d\n",i+1);
		printf ("1.\tMake a two-wire connection from channel %d \n",i+1);
		printf ("\tto the DMM current input terminals.\n");
		printf ("2.\tThe DMM is set to make DC current measurements on \n");
		printf ("\tthe 100 mA range.\n");
		printf ("3.\tFor each channel in the HP E1418A,\n");
		printf ("\t\tOutput 20 mA, 15 mA, 10 mA, 5 mA, 0 mA, -5 mA, -10 mA, -15 mA, -20 mA.\n");
		printf ("\t\tMeasure each current output.\n");
		printf ("\n\n");
		pause();
		/** current output loop **/
		for (j=0;j<9   ;j++)
		{
			err=viPrintf(dac, "APPLY%d:CURRENT %f;*OPC?\n",i+1,i_out[j]); /* voltage output */
			if(err  VI_SUCCESS) err_handler(dac, err);
			err=viScanf(dac, "%d", &opc_check);			/* enter OPC integer  */
			if(err  VI_SUCCESS) err_handler(dac, err);
			current_results [i][j] = dmm_measure();
		}
		printf ("Current Output Test on channel %d complete\n\n",i+1);
		err=viPrintf(dac, "OUTPUT%d OFF;*OPC?\n",i+1); /* Turn output off     */
		if(err  VI_SUCCESS) err_handler(dac, err);
		err=viScanf(dac, "%d", &opc_check);			/* enter OPC integer  */
		if(err  VI_SUCCESS) err_handler(dac, err);
		sys_err (dac);      /* SCPI error check */
	}
	printf ("Current Output Verification Test completed");
	err=viPrintf(dac, "*RST\n");      /* reset the dac            */
	if(err  VI_SUCCESS) err_handler(dac, err);
}
/*** End of current_check ***/
```

Performance Test Record

Table 4-1 is a form you can copy and use to record the performance verification test results of the HP E1418A. This table shows the output accuracy, measurement uncertainty, and the test accuracy ratio (TAR) values. The test marked with a "Q" in the table are the Quick Verification Tests.

Test Limits

The test limits are defined using the 90-day specifications. Appendix A lists the HP E1418A specifications.

Measurement Uncertainty

Measurement uncertainty has been calculated using the HP 34401A 90-day specifications. The HP 34401A is set to the 6½ digit mode for all calculations. In both the voltage and current measurement mode, the measurement uncertainty is given as:

M.U. = % of reading + % of range

Voltage Output Measurements

The 100 V range is used for the voltage output measurements.
The specification is given as:

M.U. = ± (0.0035% of reading + 0.0006% of range)

HP E1418A Output	% of reading	% of range	Measurement Uncertainty
+ 16.00 V	0.00056 V	0.0006 V	± 0.00116 V
+ 12.00 V	0.00042 V	0.0006 V	± 0.00102 V
+ 8.00 V	0.00028 V	0.0006 V	± 0.00088 V
+ 4.00 V	0.00014 V	0.0006 V	± 0.00074 V
0.00 V	0.00000 V	0.0006 V	± 0.00060 V
– 4.00 V	0.00014 V	0.0006 V	± 0.00074 V
– 8.00 V	0.00028 V	0.0006 V	± 0.00088 V
– 12.00 V	0.00042 V	0.0006 V	± 0.00102 V
– 16.00 V	0.00056 V	0.0006 V	± 0.00116 V

DC Compliance Current Measurements

The 100 V range is used for the compliance current test. (The compliance current is inferred from the voltage developed across the resistor).

M.U. = ± (0.035% of reading + 0.0006% of range)
M.U. = ± (0.00042 + 0.0006) = 0.00102 V

DC Short Circuit Current Measurements

The 100 mA range is used for the short circuit current measurement.

M.U. = ± (0.030% of reading + 0.005% of range)
M.U. = ± (0.000018 + 0.000005) = 0.000023 A

Current Output Measurements

The 100 mA range is used for the current output measurements.

M.U. = ± (0.030% of reading + 0.005% of range)

HP E1418A Output	% of reading	% of range	Measurement Uncertainty
+ 0.020 A	0.000006 A	0.000005 A	± 0.000011 A
+ 0.015 A	0.0000045 A	0.000005 A	± 0.0000095 A
+ 0.010 A	0.000003 A	0.000005 A	± 0.000008 A
+ 0.005 A	0.0000015 A	0.000005 A	± 0.0000065 A
0.000 A	0.00000 A	0.000005 A	± 0.000005 A
– 0.005 A	0.0000015 A	0.000005 A	± 0.0000065 A
– 0.010 A	0.000003 A	0.000005 A	± 0.000008 A
– 0.015 A	0.0000045 A	0.000005 A	± 0.0000095 A
– 0.020 A	0.000006 A	0.000005 A	± 0.000011 A

Test Accuracy Ratio (TAR)

The Test Accuracy Ratio (TAR) is defined as:

$$TAR = \frac{Maximum\ Allowed - Input}{Measurement\ Uncertainty}$$

Where *Maximum Allowed*, *Input*, and *Measurement Uncertainty* are all in Vdc or Amps.

The TAR is listed in table 4-1.

Table 4-1. Performance Test Record

Test Facility:	
Name	Report No.
Address	Date
City/State	Customer
Phone	Tested by
Model HP E1418A	Ambient Temperature
Serial No.	Relative Humidity
Options	
Firmware Rev	
Notes:	

Test Equipment Used	Model	Trace Number	Cal Due Date

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Voltage Output Check							
Q	1	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	1	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	1	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	1	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	1	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	1	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	1	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	1	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	1	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1
Q	2	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	2	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	2	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	2	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	2	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	2	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	2	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	2	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	2	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1
Q	3	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	3	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	3	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	3	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	3	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	3	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	3	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	3	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	3	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	4	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	4	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	4	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	4	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	4	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	4	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	4	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	4	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	4	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1
Q	5	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	5	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	5	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	5	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	5	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	5	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	5	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	5	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	5	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1
Q	6	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	6	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	6	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	6	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	6	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	6	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	6	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	6	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	6	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	7	+16.000 V	+15.989 V	__________	+16.011 V	1.16E-3 V	9.5:1
	7	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	7	+8.000 V	+7.993 V	__________	+8.007 V	8.80E-4 V	7.9:1
	7	+4.000 V	+3.995 V	__________	+4.005 V	7.40E-4 V	6.7:1
Q	7	0.000 V	– 0.003 V	__________	+0.003 V	6.00E-4 V	5:1
	7	-4.000 V	–4.005	__________	–3.995 V	7.40E-4 V	6.7:1
	7	-8.000 V	–8.007	__________	–7.993 V	8.80E-4 V	7.9:1
	7	-12.000 V	–12.009	__________	–11.991 V	1.02E-3 V	8.8:1
Q	7	-16.000 V	–16.011	__________	–15.989 V	1.16E-3 V	9.5:1
Q	8	+16.000 V	+15.989 V	__________	+16.011 V	1.16E-3 V	9.5:1
	8	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	8	+8.000 V	+7.993 V	__________	+8.007 V	8.80E-4 V	7.9:1
	8	+4.000 V	+3.995 V	__________	+4.005 V	7.40E-4 V	6.7:1
Q	8	0.000 V	– 0.003 V	__________	+0.003 V	6.00E-4 V	5:1
	8	-4.000 V	–4.005	__________	–3.995 V	7.40E-4 V	6.7:1
	8	-8.000 V	–8.007	__________	–7.993 V	8.80E-4 V	7.9:1
	8	-12.000 V	–12.009	__________	–11.991 V	1.02E-3 V	8.8:1
Q	8	-16.000 V	–16.011	__________	–15.989 V	1.16E-3 V	9.5:1
Q	9	+16.000 V	+15.989 V	__________	+16.011 V	1.16E-3 V	9.5:1
	9	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	9	+8.000 V	+7.993 V	__________	+8.007 V	8.80E-4 V	7.9:1
	9	+4.000 V	+3.995 V	__________	+4.005 V	7.40E-4 V	6.7:1
Q	9	0.000 V	– 0.003 V	__________	+0.003 V	6.00E-4 V	5:1
	9	-4.000 V	–4.005	__________	–3.995 V	7.40E-4 V	6.7:1
	9	-8.000 V	–8.007	__________	–7.993 V	8.80E-4 V	7.9:1
	9	-12.000 V	–12.009	__________	–11.991 V	1.02E-3 V	8.8:1
Q	9	-16.000 V	–16.011	__________	–15.989 V	1.16E-3 V	9.5:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	10	+16.000 V	+15.989 V	________	+16.011 V	1.16E-3 V	9.5:1
	10	+12.000 V	+11.991 V	________	+12.009 V	1.02E-3 V	8.8:1
	10	+8.000 V	+7.993 V	________	+8.007 V	8.80E-4 V	7.9:1
	10	+4.000 V	+3.995 V	________	+4.005 V	7.40E-4 V	6.7:1
Q	10	0.000 V	– 0.003 V	________	+0.003 V	6.00E-4 V	5:1
	10	-4.000 V	–4.005	________	–3.995 V	7.40E-4 V	6.7:1
	10	-8.000 V	–8.007	________	–7.993 V	8.80E-4 V	7.9:1
	10	-12.000 V	–12.009	________	–11.991 V	1.02E-3 V	8.8:1
Q	10	-16.000 V	–16.011	________	–15.989 V	1.16E-3 V	9.5:1
Q	11	+16.000 V	+15.989 V	________	+16.011 V	1.16E-3 V	9.5:1
	11	+12.000 V	+11.991 V	________	+12.009 V	1.02E-3 V	8.8:1
	11	+8.000 V	+7.993 V	________	+8.007 V	8.80E-4 V	7.9:1
	11	+4.000 V	+3.995 V	________	+4.005 V	7.40E-4 V	6.7:1
Q	11	0.000 V	– 0.003 V	________	+0.003 V	6.00E-4 V	5:1
	11	-4.000 V	–4.005	________	–3.995 V	7.40E-4 V	6.7:1
	11	-8.000 V	–8.007	________	–7.993 V	8.80E-4 V	7.9:1
	11	-12.000 V	–12.009	________	–11.991 V	1.02E-3 V	8.8:1
Q	11	-16.000 V	–16.011	________	–15.989 V	1.16E-3 V	9.5:1
Q	12	+16.000 V	+15.989 V	________	+16.011 V	1.16E-3 V	9.5:1
	12	+12.000 V	+11.991 V	________	+12.009 V	1.02E-3 V	8.8:1
	12	+8.000 V	+7.993 V	________	+8.007 V	8.80E-4 V	7.9:1
	12	+4.000 V	+3.995 V	________	+4.005 V	7.40E-4 V	6.7:1
Q	12	0.000 V	– 0.003 V	________	+0.003 V	6.00E-4 V	5:1
	12	-4.000 V	–4.005	________	–3.995 V	7.40E-4 V	6.7:1
	12	-8.000 V	–8.007	________	–7.993 V	8.80E-4 V	7.9:1
	12	-12.000 V	–12.009	________	–11.991 V	1.02E-3 V	8.8:1
Q	12	-16.000 V	–16.011	________	–15.989 V	1.16E-3 V	9.5:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	13	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	13	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	13	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	13	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	13	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	13	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	13	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	13	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	13	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1
Q	14	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	14	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	14	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	14	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	14	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	14	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	14	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	14	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	14	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1
Q	15	+16.000 V	+15.989 V	___________	+16.011 V	1.16E-3 V	9.5:1
	15	+12.000 V	+11.991 V	___________	+12.009 V	1.02E-3 V	8.8:1
	15	+8.000 V	+7.993 V	___________	+8.007 V	8.80E-4 V	7.9:1
	15	+4.000 V	+3.995 V	___________	+4.005 V	7.40E-4 V	6.7:1
Q	15	0.000 V	– 0.003 V	___________	+0.003 V	6.00E-4 V	5:1
	15	-4.000 V	–4.005	___________	–3.995 V	7.40E-4 V	6.7:1
	15	-8.000 V	–8.007	___________	–7.993 V	8.80E-4 V	7.9:1
	15	-12.000 V	–12.009	___________	–11.991 V	1.02E-3 V	8.8:1
Q	15	-16.000 V	–16.011	___________	–15.989 V	1.16E-3 V	9.5:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	16	+16.000 V	+15.989 V	__________	+16.011 V	1.16E-3 V	9.5:1
	16	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	16	+8.000 V	+7.993 V	__________	+8.007 V	8.80E-4 V	7.9:1
	16	+4.000 V	+3.995 V	__________	+4.005 V	7.40E-4 V	6.7:1
Q	16	0.000 V	– 0.003 V	__________	+0.003 V	6.00E-4 V	5:1
	16	-4.000 V	–4.005	__________	–3.995 V	7.40E-4 V	6.7:1
	16	-8.000 V	–8.007	__________	–7.993 V	8.80E-4 V	7.9:1
	16	-12.000 V	–12.009	__________	–11.991 V	1.02E-3 V	8.8:1
Q	16	-16.000 V	–16.011	__________	–15.989 V	1.16E-3 V	9.5:1
DC Voltage Compliance Current Check							
	1	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	2	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	3	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	4	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	5	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	6	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	7	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	8	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	9	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	10	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	11	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	12	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	13	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	14	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	15	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1
	16	+12.000 V	+11.991 V	__________	+12.009 V	1.02E-3 V	8.8:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
DC Voltage Short Circuit Current Check							
	1	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	2	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	3	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	4	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	5	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	6	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	7	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	8	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	9	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	10	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	11	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	12	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	13	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	14	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	15	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
	16	+16.000 V	NA	___________	0.060 A	2.3E-5 A	NA
DC Current Output Check							
Q	1	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	1	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	1	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	1	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	1	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	1	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	1	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	1	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	1	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	2	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	2	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	2	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	2	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	2	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	2	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	2	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	2	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	2	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	3	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	3	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	3	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	3	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	3	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	3	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	3	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	3	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	3	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	4	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	4	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	4	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	4	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	4	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	4	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	4	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	4	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	4	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	5	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	5	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	5	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	5	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	5	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	5	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	5	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	5	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	5	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	6	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	6	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	6	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	6	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	6	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	6	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	6	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	6	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	6	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	7	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	7	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	7	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	7	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	7	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	7	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	7	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	7	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	7	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	8	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	8	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	8	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	8	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	8	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	8	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	8	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	8	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	8	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	9	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	9	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	9	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	9	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	9	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	9	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	9	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	9	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	9	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	10	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	10	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	10	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	10	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	10	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	10	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	10	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	10	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	10	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	11	+0.02000 A	+0.019977 A	__________	+0.020023 A	1.10E-5 A	2.1:1
	11	+0.01500 A	+0.0149815 A	__________	+0.0150185 A	9.50E-6 A	1.9:1
	11	+0.01000 A	+0.009986 A	__________	+0.010014 A	8.00E-6 A	1.7:1
	11	+0.00500 A	+0.0049905 A	__________	+0.0050095 A	6.50E-6 A	1.5:1
Q	11	0.00000 A	–0.000005 A	__________	+0.000005 A	5.00E-6 A	1:1
	11	–0.00500 A	–0.0050095 A	__________	–0.0049905 A	6.50E-6 A	1.5:1
	11	–0.01000 A	–0.010014 A	__________	–0.009986 A	8.00E-6 A	1.7:1
	11	–0.01500 A	–0.0150185 A	__________	–0.0149815 A	9.50E-6 A	1.9:1
Q	11	–0.02000 A	–0.020023 A	__________	–0.019977 A	1.10E-5 A	2.1:1
Q	12	+0.02000 A	+0.019977 A	__________	+0.020023 A	1.10E-5 A	2.1:1
	12	+0.01500 A	+0.0149815 A	__________	+0.0150185 A	9.50E-6 A	1.9:1
	12	+0.01000 A	+0.009986 A	__________	+0.010014 A	8.00E-6 A	1.7:1
	12	+0.00500 A	+0.0049905 A	__________	+0.0050095 A	6.50E-6 A	1.5:1
Q	12	0.00000 A	–0.000005 A	__________	+0.000005 A	5.00E-6 A	1:1
	12	–0.00500 A	–0.0050095 A	__________	–0.0049905 A	6.50E-6 A	1.5:1
	12	–0.01000 A	–0.010014 A	__________	–0.009986 A	8.00E-6 A	1.7:1
	12	–0.01500 A	–0.0150185 A	__________	–0.0149815 A	9.50E-6 A	1.9:1
Q	12	–0.02000 A	–0.020023 A	__________	–0.019977 A	1.10E-5 A	2.1:1
Q	13	+0.02000 A	+0.019977 A	__________	+0.020023 A	1.10E-5 A	2.1:1
	13	+0.01500 A	+0.0149815 A	__________	+0.0150185 A	9.50E-6 A	1.9:1
	13	+0.01000 A	+0.009986 A	__________	+0.010014 A	8.00E-6 A	1.7:1
	13	+0.00500 A	+0.0049905 A	__________	+0.0050095 A	6.50E-6 A	1.5:1
Q	13	0.00000 A	–0.000005 A	__________	+0.000005 A	5.00E-6 A	1:1
	13	–0.00500 A	–0.0050095 A	__________	–0.0049905 A	6.50E-6 A	1.5:1
	13	–0.01000 A	–0.010014 A	__________	–0.009986 A	8.00E-6 A	1.7:1
	13	–0.01500 A	–0.0150185 A	__________	–0.0149815 A	9.50E-6 A	1.9:1
Q	13	–0.02000 A	–0.020023 A	__________	–0.019977 A	1.10E-5 A	2.1:1

Quick Check	Channel	E1418A Output	Min	Measured	Max	M.U.	TAR
Q	14	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	14	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	14	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	14	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	14	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	14	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	14	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	14	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	14	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	15	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	15	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	15	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	15	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	15	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	15	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	15	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	15	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	15	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1
Q	16	+0.02000 A	+0.019977 A	___________	+0.020023 A	1.10E-5 A	2.1:1
	16	+0.01500 A	+0.0149815 A	___________	+0.0150185 A	9.50E-6 A	1.9:1
	16	+0.01000 A	+0.009986 A	___________	+0.010014 A	8.00E-6 A	1.7:1
	16	+0.00500 A	+0.0049905 A	___________	+0.0050095 A	6.50E-6 A	1.5:1
Q	16	0.00000 A	–0.000005 A	___________	+0.000005 A	5.00E-6 A	1:1
	16	–0.00500 A	–0.0050095 A	___________	–0.0049905 A	6.50E-6 A	1.5:1
	16	–0.01000 A	–0.010014 A	___________	–0.009986 A	8.00E-6 A	1.7:1
	16	–0.01500 A	–0.0150185 A	___________	–0.0149815 A	9.50E-6 A	1.9:1
Q	16	–0.02000 A	–0.020023 A	___________	–0.019977 A	1.10E-5 A	2.1:1

Notes

Chapter 5
Adjustments

Introduction

This chapter contains procedures for adjusting the calibration constants in the HP E1418A. Run the Performance Tests (described on Chapter 4) before any adjustments to characterize the module. Run the Performance Tests after any adjustments to verify the adjustments made. The module should be adjusted following any reconfiguration or repair.

Hewlett-Packard Calibration Services

Contact the local Hewlett-Packard Service Center for low cost calibration services. The HP E1418A is supported on automated calibration systems which allow calibration at competitive prices. Calibrations to MIL-STD-45662 are also available.

Calibration Interval

The HP E1418A 8/16 Channel D/A Converter Module should be calibrated on a regular interval determined by the accuracy requirements of you application. Hewlett-Packard recommends calibration every 90 days for most applications. Demanding applications may require a daily calibration cycle. Hewlett-Packard does not recommend extending the calibration interval beyond one year in any application.

Whatever calibration interval you use, Hewlett-Packard recommends that a complete adjustment be performed. This increases confidence that the module will remain in specification for the next calibration interval and provides the best measure of the module's long-term stability. Performance Verification Test data can be used to extend or determine future calibration intervals.

Closed-Cover Electronic Calibration

The HP E1418A features closed-cover electronic calibration. There are no internal mechanical adjustments. Once properly installed, the module can be tested and adjusted using connections to a terminal module.

WARNING

Do not perform any of the following adjustment procedures unless you are a qualified, service trained technician and have read the warnings on page 6 and the warnings and cautions beginning on page 10.

Calibration Constants and Non-Volatile Memory

The accuracy of a channel output depends upon a number of calibration constants. Calibration constants are stored in two locations within the module; in non-volatile memory and in RAM. The constants in RAM are used by the module to adjust all outputs during use.

When the module is used with the SCPI driver, the RAM constants are loaded from the non-volatile memory at power-up. You can adjust the RAM calibration constants without disturbing the non-volatile memory constants (creating a *temporary* adjustment).

Non-volatile memory has a finite number of writes. Writing the calibration constants to non-volatile memory, therefore, reduces the life of this memory. If you are calibrating the module at 90 day or 1 year intervals, write the new constants into non-volatile memory. The new constants will be used following power-up. If you are adjusting the module more frequently (i.e., daily), write the new calibration constants into RAM, but do not write to non-volatile memory.

The adjustment procedures in this chapter demonstrate both methods of writing calibration constants.

Making Connections

All adjustments can be performed using the CAL output terminals. The CAL output terminals provide one set of connections for both voltage and current adjustment. Procedures in this chapter assume connections are made at the CAL output terminals on the screw-type terminal module.

Note

For demanding applications or for adjustment using the intended load, you can perform the adjustment at each channel output (to include the output relay contacts, wiring, and the load in the path). To make the adjustments at each channel output, use the **DIAG:CAL:OUTP CHAN** command to set the adjustment point at the channels instead of the CAL output terminals. Adjustment at each channel output will require individual four-wire connections.

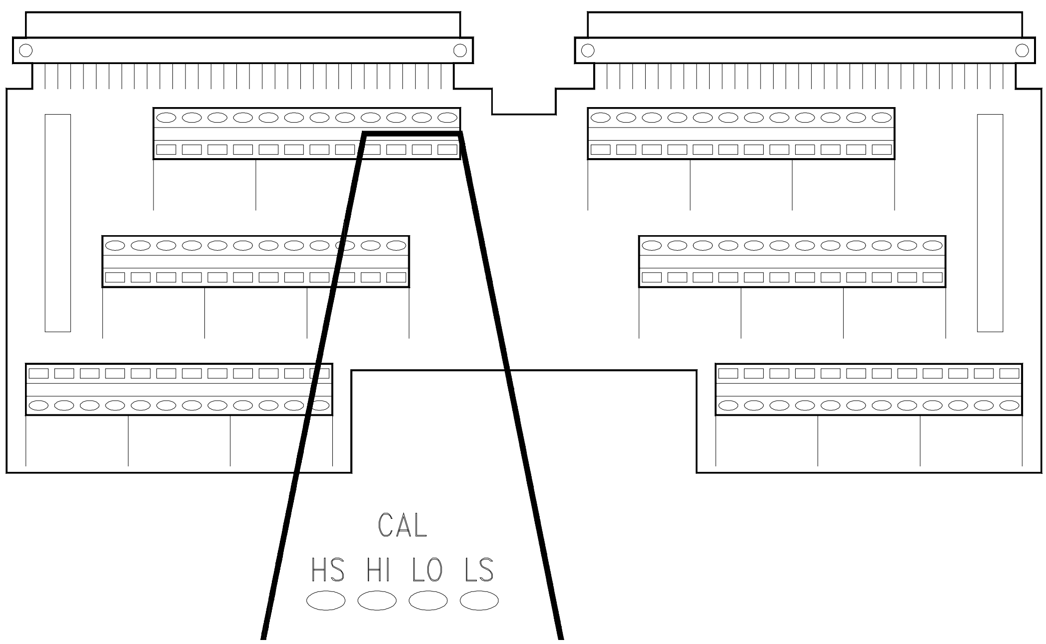


Figure 5-1. CAL Output Terminals

Adjustment Procedure

Adjustment is performed on each channel, one at a time. Voltage output and current output each use unique calibration constants.

Preparation

Before performing any adjustments, determine if the adjustments are to be temporary or permanent (refer to the discussion on page 60).

If Permanent

1. Turn off the mainframe.
2. Remove the terminal module.
3. Remove the module from the mainframe.

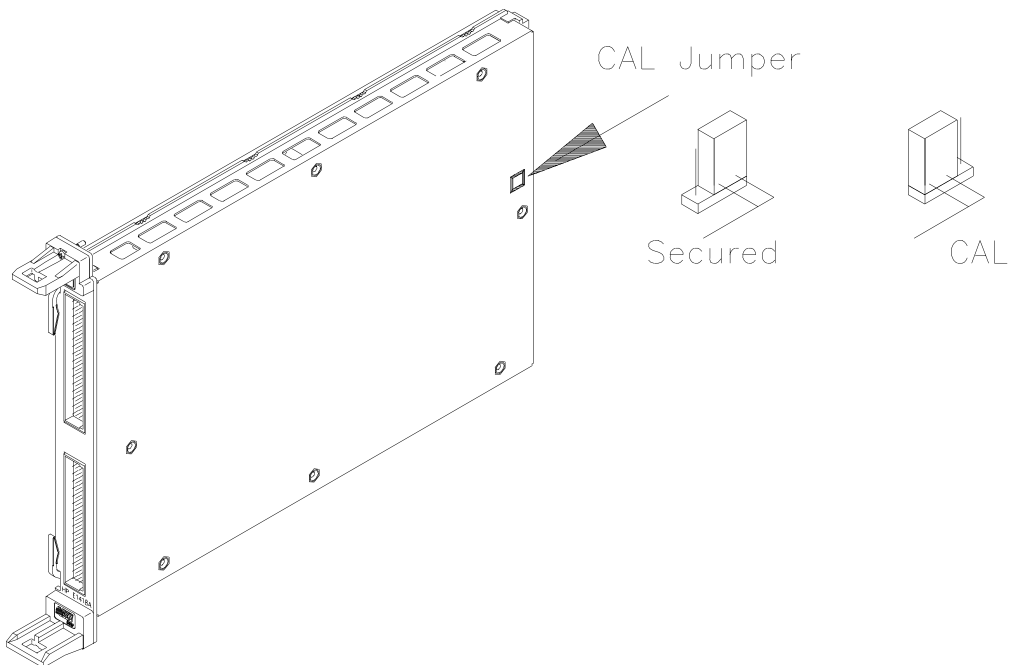


Figure 5-2. Cal Store Enable Jumper

4. Set the Cal Store Enable Jumper to the CAL position as shown below.
5. Re-install the module in the mainframe.
6. Make the CAL output terminal connections on the terminal module.
7. Install the terminal module.
8. Apply power and allow a 15 minute warm-up.

If Temporary

1. Make the CAL output terminal connections on the terminal module.
2. Install the terminal module.
3. Apply power and allow a 15 minute warm-up.

Voltage Adjustment

Voltage output adjustment uses two of the CALibration subsystem queries.

CALibration*n*:CONFigure:VOLTage?
CALibration*n*:VALue:VOLTage? <*value*>

The general procedure for channel voltage adjustment is:

1. Make the connections shown in figure 5-3 or 5-4.
2. Send the **CAL*n*:CONF:VOLT?** query to the module and read the response until a 1 is returned (typically the first query response).
3. Read the voltage output on the DMM.
4. Send the DMM value read with the **CAL*n*:VAL:VOLT? *value*** query.
5. Enter the query response.
6. Repeat steps 3, 4, and 5 until the **CAL*n*:VAL:VOLT? *value*** query returns a 0.
7. Repeat steps 1 through 6 for each channel.

The first query, **CAL*n*:CONF:VOLT?**, sets the channel to the calibration mode and returns a 1 when the channel is ready for calibration. When a 1 is returned, the channel output voltage is set to the first adjustment point.

Read the output voltage on the DMM and return the value obtained using the **CAL*n*:VAL:VOLT? *value*** query. This query returns an integer indicating the calibration state of the channel. Any non-zero return from this query indicates additional values are needed.

Each channel will require multiple iterations of the **CAL*n*:VAL:VOLT? *value*** query. A minimum of 9 queries, to a maximum of 50 queries, will be required at each channel. During the process, the output voltage will range from +16 V to -16 V and the last values output will be at or near 0 volts.

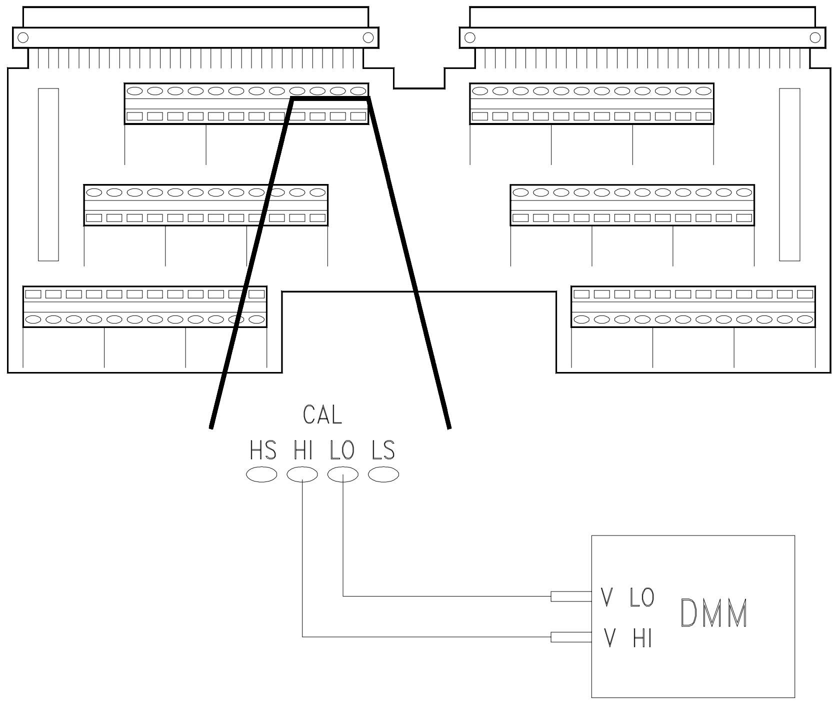


Figure 5-3. Voltage Adjustment Connections (CAL)

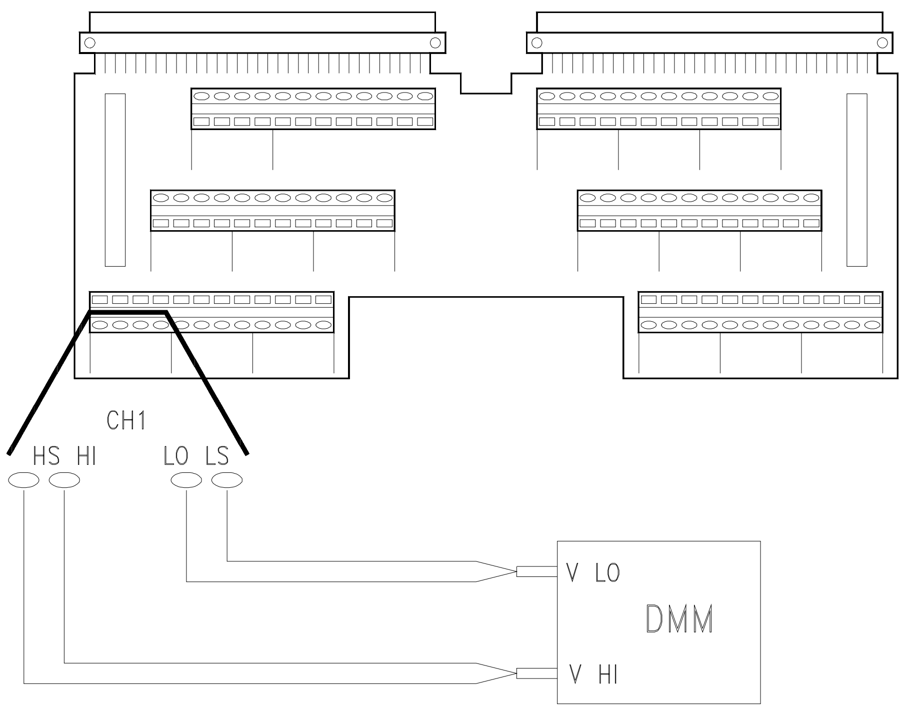


Figure 5-4. Optional Voltage Adjustment Connections

Current Adjustment

Current output uses an internal resistance value to calibrate all channels. This resistance value is approximately 244 Ω.. The current is output adjusted by measuring the voltage developed across this resistor.

Note

You may also, optionally, use an external resistance value (or load) on each channel for current output and calibration. If you wish to specify an external resistor value, you must send the **DIAG:CAL:OUTP CHAN** command and perform the adjustment at each channel output. Any load value may be used but values in the range of 50 Ω to 500 Ω are recommended.

Note that during the adjustment process self-heating of the external load may affect the adjustment.

To set the internal resistance value use the following CALibration commands:

CALibration:CONFigure:RESistance?
CALibration:VALue:RESistance <*value*>

The resistance value set, either internal or external, is not stored.

When using the **internal resistor value**, the general procedure is:

1. Make the connections shown in Figure 5-5.
2. Send the **CALibration:CONFigure:RESistance?** query to the module and read the response until a 1 is returned (typically the first query response).
3. Read the resistance on the DMM.
4. Send the DMM value read to the module using the **CALibration:VALue:RESistance <*value*>** command.

The resistor value is only set once for current calibration of all channels.

Optional

If you are using an **external resistor value**, *for each channel*:

1. Send the **CALibration:CONFigure:RESistance?** query to the module and read the response until a 1 is returned (typically the first query response).
2. Measure the channel's external resistor value on the DMM.
3. Send the DMM value read to the module using the **CALibration:VALue:RESistance <*value*>** command.

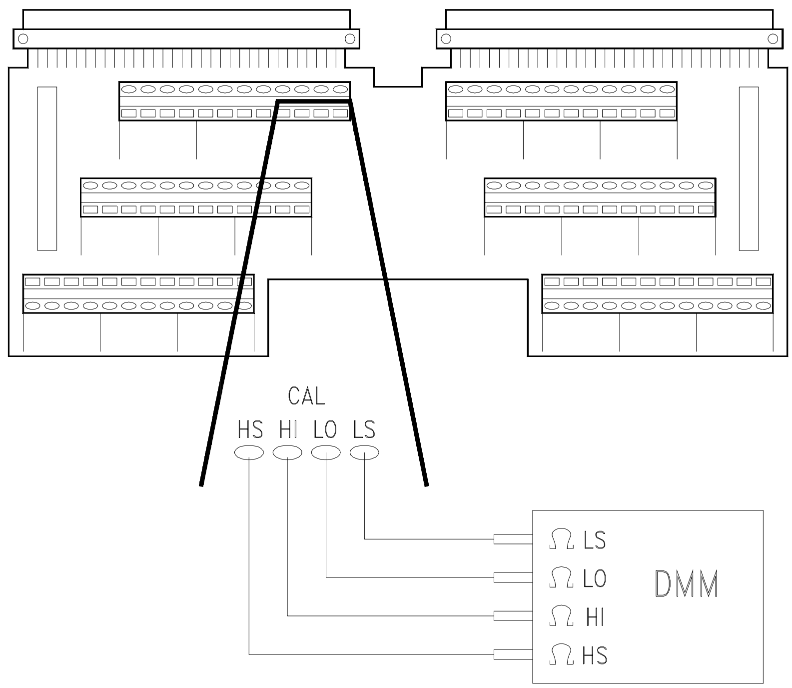


Figure 5-5. Internal Resistor Adjustment Connections

Current output adjustment uses two of the CALibration subsystem queries. Current adjustment requires voltage measurements.

CALibration*n*:CONFigure:CURRent?
CALibration*n*:VALue:CURRent? <*value*>

Note

The current adjustment procedure measures and inputs a *voltage* value developed across a known resistor value (set at the start of the procedure).

Once the calibration resistance value is set as described earlier, the general procedure for each channel current output adjustment is:

1. Make the connections shown in figure 5-6 or 5-7.
2. Send the **CAL*n*:CONF:CURR?** query to the module and read the response until a 1 is returned (typically the first query response).
3. Read the *voltage* on the DMM.
4. Send the DMM value read with the **CAL*n*:VAL:CURR? <*value*>** query.
5. Enter the query response.
6. Repeat steps 3, 4, and 5 until the **CAL*n*:VAL:CURR? <*value*>** query returns a 0.
7. Repeat steps 1 through 6 for each channel.

The first query, **CAL*n*:CONF:CURR?**, sets the channel to the calibration mode and returns a 1 when the channel is ready for calibration. When a 1 is returned, the channel output voltage is set to the first adjustment point.

Read the *voltage* on the DMM and return the value obtained using the **CAL*n*:VAL:CURR? <*value*>** query. This query returns an integer indicating the calibration state of the channel. A value other than 0 or 2 from this query indicates additional values are needed.

Each channel will require multiple iterations of the **CAL*n*:VAL:CURR? <*value*>** query. A minimum of 9 queries, to a maximum of 50 queries, will be required at each channel. During the process, the output voltage will range from -5 to +5 V and the last values output will be at or near 0 volts.

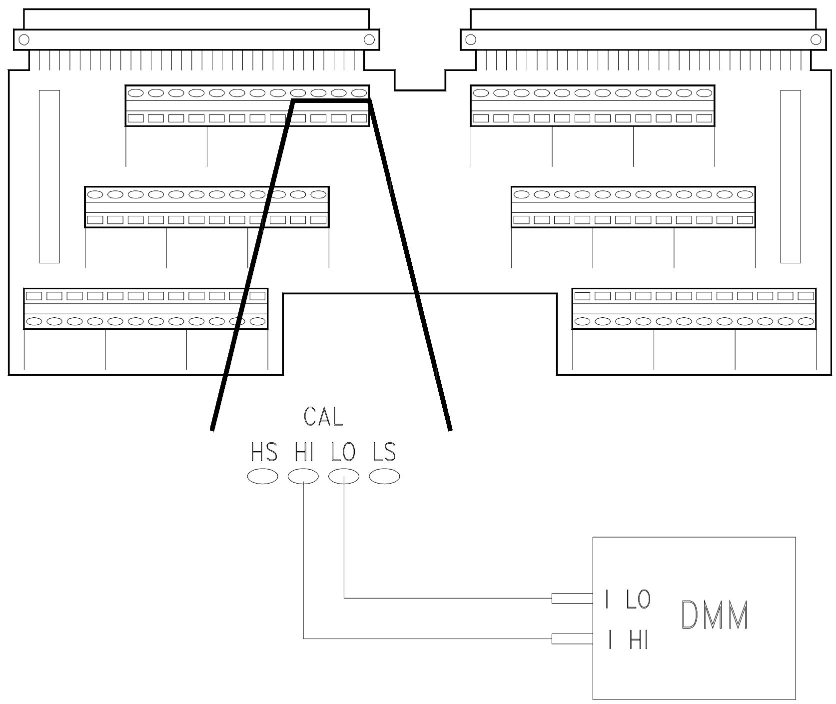


Figure 5-6. Current Adjustment Connections (CAL)

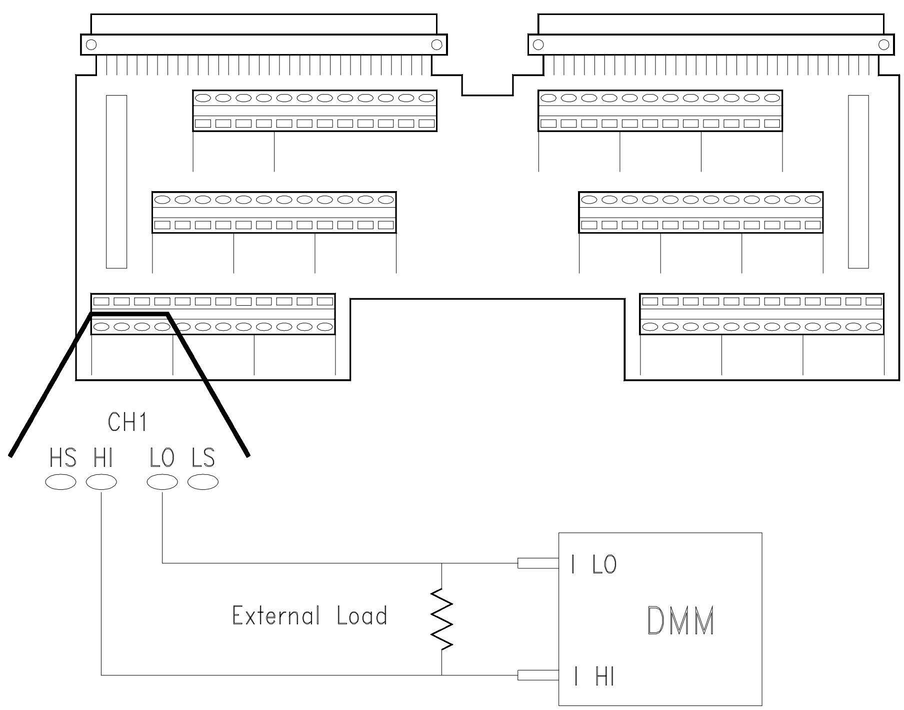


Figure 5-7. Optional Current Adjustment Connections

Storing the Adjustments

Once all adjustments have been made, you can store the new calibration constants in non-volatile memory by sending the following command:

```
/* Store the new constants   */
CALibration:STORe
```

This command will generate an error if the Cal Store Enable Jumper is not set to the CAL position (see page 62).

Note

The HP E1418A will be busy storing the new calibration constants following the CAL:STOR command. You should not perform any bus resets or module resets until the store is complete. You can use the *OPC? query to determine when the command has finished.

Verify the Adjustments

Run the Performance Verification Tests, beginning on page 34, to verify the adjustments made.

Return the Module to Use

If you have changed the position of the Cal Store Enable Jumper (as described on page 62) and you wish to prevent writing calibration constants to non-volatile memory, set the jumper to the SECURE position.

If you have changed the position of the terminal jumpers, as described on page 16, return the jumpers to their original positions.

Example Program

The following program, written in ANSI C illustrates a full calibration of all channels for both voltage and current. The internal calibration resistor is used. The disk provided with this manual contains a calibration example file. This example uses function calls to the HP VISA Transition Library for I/O operations.

```
                    •
                    •
                    •
 /**  FUNCTION PROTOTYPES  **/
void main (void);
void err_handler(ViSession vi, ViStatus x);     /* VTL error routine                 */
void sys_err(ViSession resource);               /* Checks for SCPI programming errors  */
void pause();                       /* Waits for a keystroke to continue program execution  */
int config_check ();                            /* Checks and reports the module configuration */
                                    /* returns the number of channels in module      */
float get_voltage ();                          /* Obtains the measured voltage        */
float get_resistance ();                       /* Obtains the measured resistance  */
                    •
                    •
                    •
void main (void)
    {
    char cal_point [5],int_ext [4];
    int num_chan,result,compare,i,condition [4];
    float meas_volt,meas_res;
                    •
                    •
                    •
/***      VOLTAGE OUTPUT ADJUSTMENT                ***/
    for (i=1;i<num_chan+1;i++)
        {
        result = 0;
        while (result < 1)
            {
        err=viPrintf(dac, "CAL%d:CONF:VOLT?\n",i); /* Configure for calibration */
        if(err < VI_SUCCESS) err_handler(dac, err);
        err=viScanf(dac, "%d", &result);                    /* Enter integer returned                    */
                                                /* returns a 1 when ready to calibrate */
        if(err < VI_SUCCESS) err_handler(dac, err);
        }
    result = 1;
    while (result !=0)
        {
        meas_volt=get_voltage ();                      /* Get the voltage measurement */
        err=viPrintf(dac, "CAL%d:VAL:VOLT? %f\n",i,meas_volt); /* Send the measurement*/
```

```
		if(err < VI_SUCCESS) err_handler(dac, err);
		err=viScanf(dac, “%d”, &result);		/* Enter integer returned			*/
							/*  returns a 0 when calibration complete */
		if(err < VI_SUCCESS) err_handler(dac, err);
		if (result == 5)				/* Calibration for this channel aborted	*/
			{
			printf (“Calibration for channel %d aborted\n”,i);
			result = 0;
			}
		}
	}

/***	CURRENT OUTPUT ADJUSTMENT			***/

/*** set the calibration resistor value		***/
	result = 0;
	while (result != 1)
		{
		err=viPrintf(dac, “CAL:CONF:RES?\n”);	/* Configure for resistance calibration */
		if(err < VI_SUCCESS) err_handler(dac, err);
		err=viScanf(dac, “%d”, &result);		/* Enter integer returned			*/
							/* returns a 1 when ready to calibrate		*/
		if(err < VI_SUCCESS) err_handler(dac, err);
		}
	meas_res = get_resistance();
	err=viPrintf(dac, “CAL:VAL:RES %f\n”,meas_res); /* Send the resistance value  */
	if(err < VI_SUCCESS) err_handler(dac, err);
```

```
/*** channel current output adjustment   ***/

        for (i=1;i<num_chan+1;i++)
                {
                result = 0;
                while (result != 1)
                        {
                        err=viPrintf(dac, "CAL%d:CONF:CURR? \n",i); /* Configure for calibration */
                        if(err < VI_SUCCESS) err_handler(dac, err);
                        err=viScanf(dac, "%d", &result);        /* Enter integer returned           */
                                                               /*, returns a 1 when ready to calibrate */
                        if(err < VI_SUCCESS) err_handler(dac, err);
                        }
                result = 1;
                while (result !=0 && result !=2)
                        {
                        meas_volt=get_voltage ();               /* Get the voltage measurement */
                        err=viPrintf(dac, "CAL%d:VAL:CURR? %f\n",i,meas_volt);
                        if(err < VI_SUCCESS) err_handler(dac, err);
                        err=viScanf(dac, "%d", &result);          /* Enter integer returned           */
                                                                /* returns a 0 when calibration complete */
                        if(err < VI_SUCCESS) err_handler(dac, err);
                        if (result == 5)                        /* Calibration aborted */
                                {
                                printf ("Calibration for channel %d aborted\n\n",i);
                                result = 0;
                                }
                        }
                }

/*** STORE THE NEW CALIBRATION CONSTANTS        ***/

        err=viPrintf(dac, "CAL:STOR;*OPC?\n");        /* Store the new cal constants */
        if(err < VI_SUCCESS) err_handler(dac, err);
        err=(viScanf(dac,"%d",&result);
        if(err < VI_SUCCESS) err_handler(dac, err);
        sys_err(dac);

                        •

                        •

                        •

}
```

Chapter 6
Service

Introduction

This chapter contains troubleshooting, repair and maintenance guidelines.

WARNING

Do not perform any of the service procedures shown unless you are a qualified, service-trained technician, and have read the warning on page 6 and the warnings and cautions beginning on page 10.

Equipment Required

Test equipment required is listed in Table 1-1 on page 14. Any equipment that satisfies the requirements listed in the table may be used.

The HP E1418A uses Torx head screws. To avoid damage to the screw head slots, use only a Torx driver for disassembly and assembly. You will need a T10 Torx driver (HP Part Number 8710-1284).

Service Aids

Service aids, manual updates, and service literature may be available for the HP E1418A. For information, contact your nearest Hewlett-Packard Sales and Service Office.

Troubleshooting

This section will help isolate a failing assembly.

Visual Checks

Before installing or operating the module, visually inspect the rear panel and front panel connectors for bent pins. Inspect circuit boards for evidence of arcing or excessive heat.

If a module does not respond to commands, verify the Logical Address setting. The *HP E1418A User's Guide* describes this switch setting.

Catastrophic Failures

If a module does not respond, verify the power fuses F1, F2, F3 and F4. Disassembly is described beginning on page 80 and the locations of the fuses is shown in the drawing on page 90.

Self-Test

The internal self-test can be used to isolate most failures of the module. The major assemblies of the HP E1418A are available on an exchange basis.

Use the following SCPI Common Command query to initiate a module self-test.

```
/* Start the Self-test*/
*TST?
/* Enter the 16-bit integer returned*/
```

The query will return a +0 if no errors are encountered. Any return other than +0 indicates a failure. The command returns the *first* test to fail, additional failures are possible.

The ***TST?** query initiates a full self-test. You can obtain the complete test results by using the **TEST:TST:RESults?** query. This query returns an array of 100 integers representing the results of each self-test.

Use the following SCPI commands to initiate a self-test and obtain complete results.

```
/* Start the Self-test*/
*TST?
/* Enter the 16-bit integer returned*/
/* If the returned value is not +0, send*/
```

```
TEST:TST:RES?
/*Enter an array of 100 integers*/
```

The integers returned from the self test query have the form:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Use	Test Number								A24		Test Information					

General Self-Test

The test number returned by the ***TST?** query can be used to isolate a failing assembly. The possible test numbers and probable failing assembly are shown below.

Test Number	Failing Assembly Indicated	Notes
0	None	All Self-tests passed
1	Main Board	
2 through 9	Main Board or Plug-On Modules	Test 2 = channel 1, Test 3 = channel 2, etc.
10 through 17	Expansion Board or Plug-on Modules	Test 10 = channel 9, Test 11 = channel 10, etc.
18 through 25	Main Board	
26 through 33	Main Board	
34 through 41	Expansion Board	
42 through 43	Main Board	
44 through 51	Main Board	
52 through 59	Expansion Board	
60 through 67	Main Board	
68 through 75	Expansion Board	

Note

Since the ***TST?** query returns only the first failure test number, additional failures are possible but not reported by this query. The complete test results can be obtained using the **TEST:TST:RES?** query after the ***TST?** query.

Detailed Self-Test

Following the ***TST?** query, the **TEST:TST:RESults?** query returns complete self-test details. The following table lists each self-test and the areas checked.

Test Number	A24 Value	Test Information Value If Failed	Areas Checked
1	0	1	Relay Control Register
	0	2	A/D multiplexer
2 through 17	0	Channel Number	First DAC check of each channel
18	0 for A16 read 1 for A16 read in A24 window 2 for A16 read in A24	Register Address	ID Register, Device Type Register, VXI Offset Register, Card Configuration Register, Isolation Status Register, Channel Program Jumper Register
19	0 for A16 read/write 1 for A16 read/write via A24 window	Register Value	VXI Control Register
20	0	Register Value	VXI Control Register VXI Status Register
21	0	Register Value	Cal Control Register
22	Lower 8 bits of failed register value		Channel Mode Register
23	0 for A16 writes A16 reads 1 for A16 writes A24 reads 2 for A24 writes A16 reads 3 for A24 writes A24 reads	Register Value	Card Control Register
24	0	Checksum Error	Non-volatile memory checksum
25	Register Value		Trigger Control Register
26 through 41 (Test 26 = Ch 1 Test 41 = Ch 16)	0	1	Channel SW Trigger Register
	0	2	Channel WriteThru Register
	0	3	Channel Output
	0	4	Channel Triggered Register
	0	5	Channel Output
	0	6	Channel SW and Trigger Registers
	0	7 through 16	Channel SW and Triggered Registers
	0	17	Channel Triggered Register
	0	18	Channel Output
	0	19	Channel SW and Triggered Registers
	0	20	Channel Output

Test Number	A24 Value	Test Information Value If Failed	Areas Checked
42	0	Register Value	Interrupt Control Register
43	0	1 through 5	Interrupt Status Register, SW Trigger Register, and trig ignored bit
44 through 59 (Test 44 = Ch 1 Test 59 = Ch 16)	0	1 through 5	Voltage mode, Set the Gain/Offset Register to nominal and 5 incrementing values, read the values in the Calibration Control Register
	0	6	Check linearity of values
	0	7	Gain Register set to minimum, Channel Writethru register set to 1 V, read the Calibration Control Register
	0	8	Gain Register set to maximum, read the Calibration Control Register, calculate change from previous test
	0	9	Gain Register set to nominal, Offset Register set to minimum, Channel Writethru register set to -1 V, read the Calibration Control Register
	0	10	Offset Register set to maximum, read the Calibration Control Register, calculate change from previous test
60 through 75 (Test 60 = Ch 1 Test 75 = Ch 16)	0	1 through 5	Current mode, Set the Gain/Offset Register to nominal and 5 incrementing values, read the values in the Calibration Control Register
	0	6	Check linearity of values
	0	7	Gain Register set to minimum, Channel Writethru register set to 1 V, read the Calibration Control Register
	0	8	Gain Register set to maximum, read the Calibration Control Register, calculate change from previous test
	0	9	Gain Register set to nominal, Offset Register set to minimum, Channel Writethru register set to -1 V, read the Calibration Control Register
	0	10	Offset Register set to maximum, read the Calibration Control Register, calculate change from previous test
76 through 100	0	0	Not Used

Single Channel Failures

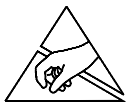
A single channel failure, not caught by the self-test, can be caused by one of two components: the channel plug-on module or the channel output relay.

To help isolate a plug-on module, disassemble the module and swap two plug-on modules. DO NOT operate the module without a plug-on module installed for every channel.

If a channel still fails after swapping the plug-on modules,suspect the channel output relay.

Repair/Maintenance Guidelines

Electrostatic Discharge (ESD) Precautions



Almost all electrical components can be damaged by electrostatic discharge (ESD) during handling. Component damage can occur at electrostatic discharge voltages as low as 50 volts. Observe the following guidelines when servicing the HP E1418A.

- Disassemble and reassemble *only* in a static-free work area.
- Remove all plastic, styrofoam, vinyl, paper, and other static-generating materials from the immediate work area.
- Use a conductive work area to dissipate static charge.
- Use a conductive wrist strap to dissipate static charge.
- Minimize handling.
- Do not stack assemblies.
- Use only anti-static solder suckers, soldering irons, and tools.
- Keep replacement parts in original static-free packaging.

Surface Mount Repair

The HP E1418A uses surface mount components. Surface mount components should *only* be removed using soldering irons or desoldering stations expressly designed for surfacemount components. *Use of conventional soldering equipment will almost always result in permanent damage to the printed circuit board and will void your Hewlett-Packard warranty.*

Disassembly

Tools Needed

- T10 Torx Driver.
- Static-Safe Workstation.
- Static Wrist Strap.

CAUTION

Almost all electrical components can be damaged by electrostatic discharge (ESD) during handling. Component damage can occur at electrostatic discharge voltages as low as 50 volts. Disassemble and re-configure *only* in a static free work area. Minimize handling of assemblies and components. Keep all assemblies and replacement parts in the original static free packaging.

These procedures should be performed by qualified service personnel at approved static-safe workstations.

Disassembly Procedure

Refer to Figures 6-1 and 6-2 during these procedures.

1. Remove the 8 T-10 torx screws in the top cover and remove the top cover.
2. Remove the T-10 Torx screw holding the sheet metal spacer or expansion board.
   a. If the HP E1418A is an 8 channel device, lift the sheet metal spacer off the main board.
   b. If the HP E1418A is a 16 channel device, carefully separate the expansion board and main board printed circuit assemblies. The two boards are joined by three electrical connectors.
3. The main board and expansion board each have 8 plug-on assemblies. To remove the plug-on assemblies, remove the T-10 Torx screw securing the plug-on assembly. Lift the plug-on assembly off the electrical connector. The plug-on assembly locations are shown in Figure 6-3.

Reassembly procedure

1. Replace all plug-on assemblies. DO NOT operate the module without a plug-on assembly installed. The plug-on assemblies have a locator hole to ensure correct orientation, see Figure 6-4.
2. Replace the expansion board or sheet-metal spacer.
3. Replace the top cover.

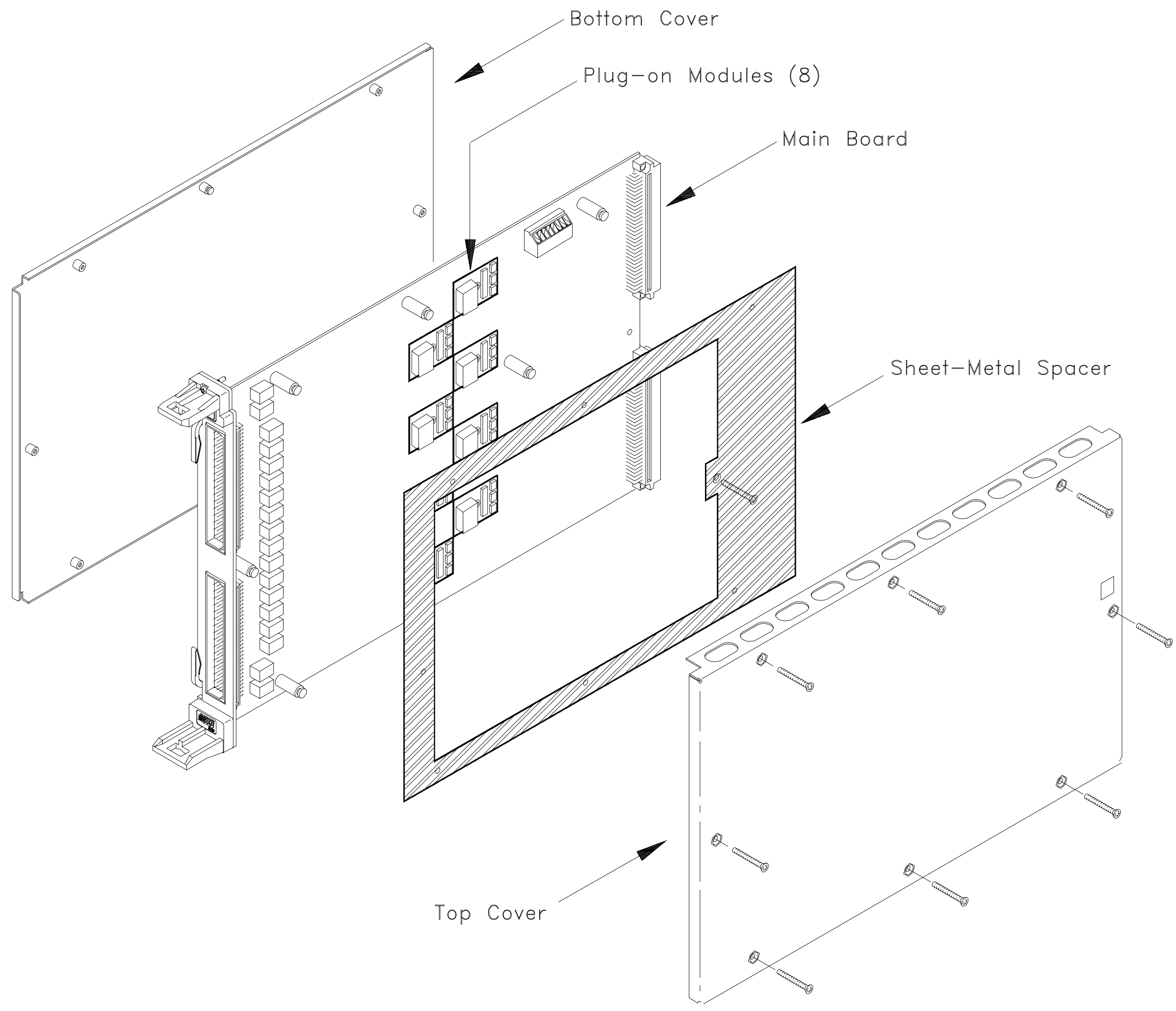


Figure 6-1. 8-Channel Disassembly

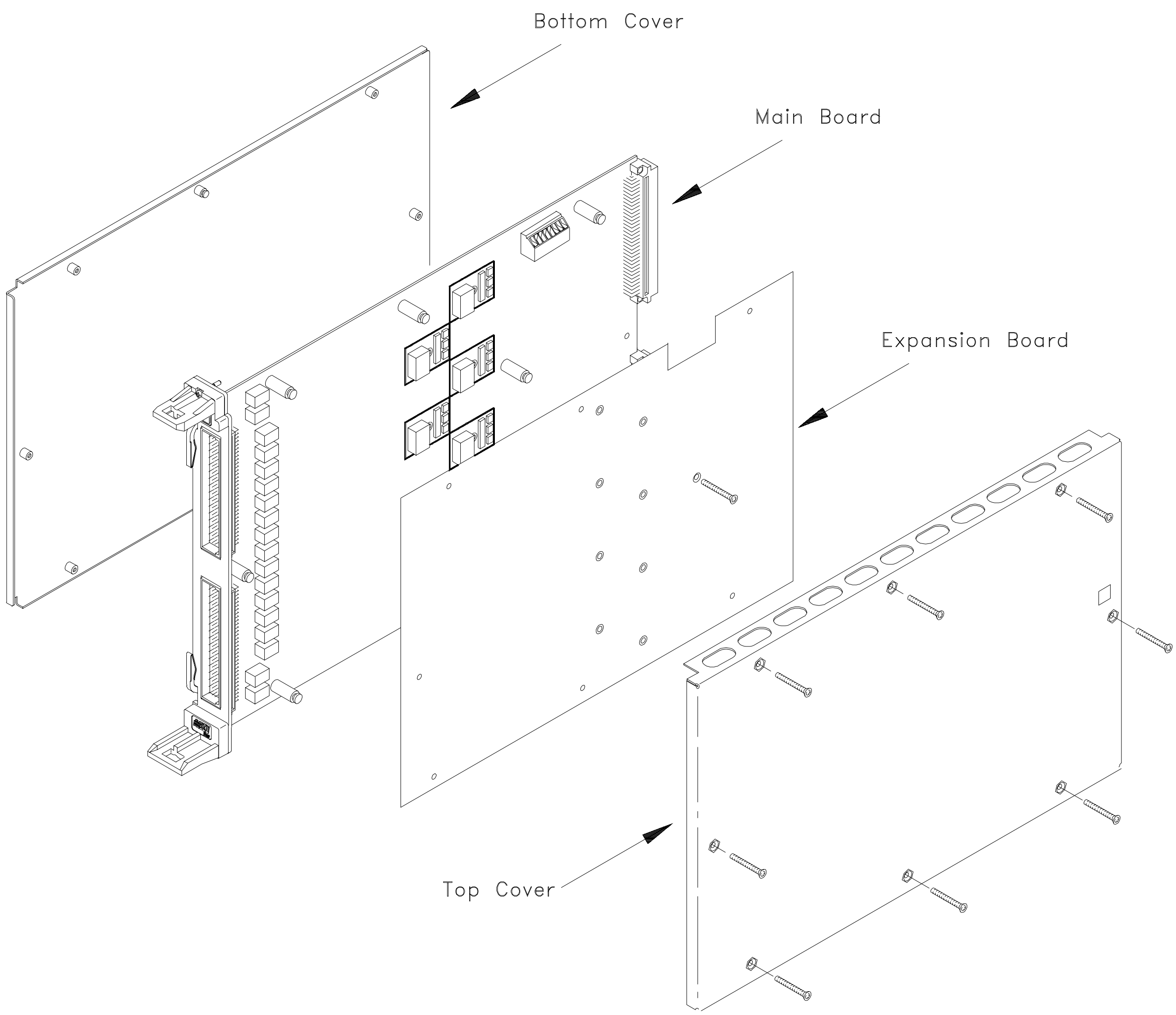


Figure 6-2. 16-Channel Disassembly

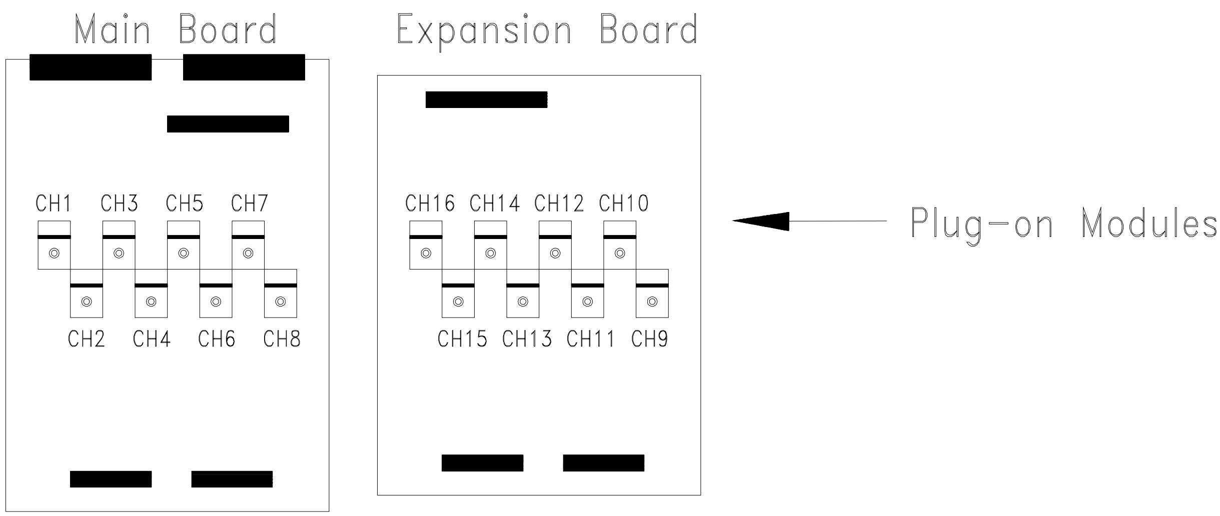


Figure 6-3. Plug-on Channel Locations

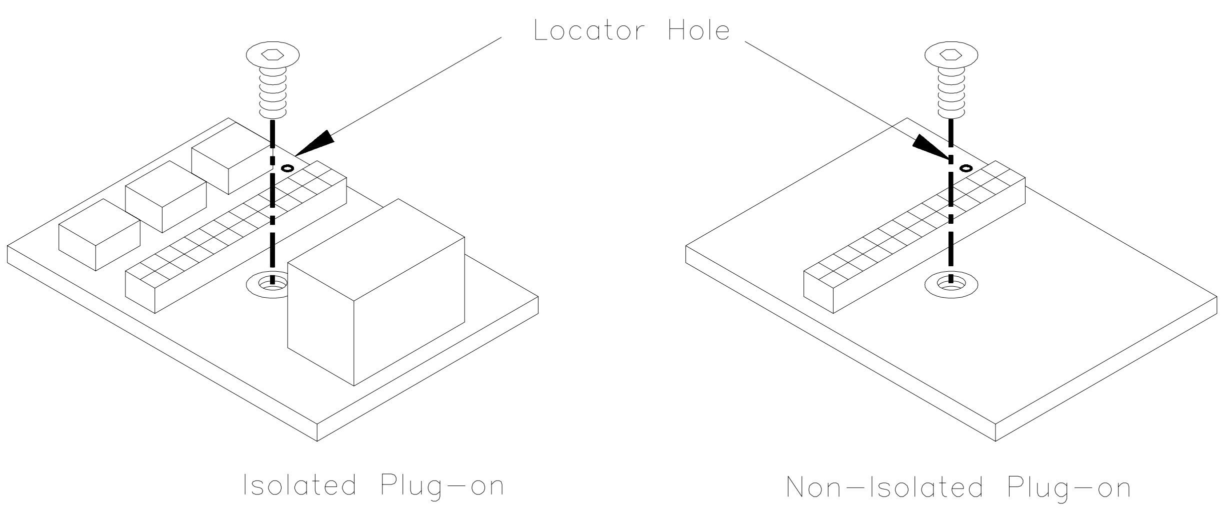


Figure 6-4. Installing Plug-on Modules

Notes

Chapter 7
Replaceable Parts

Introduction

This chapter contains the following topics:

- Assembly Exchange
- Ordering Information
- Replaceable Parts

Assembly Exchange

The following assemblies are available for exchange.

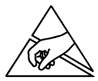
Part number	Assembly
E1418-69201	Main board and all sheet metal. Does NOT include plug-on assemblies or expansion board.
E1418-69502	Expansion board. Does NOT include plug-on assemblies.
E1418-66503	Isolated plug-on module (replacement, not an exchange).

Notes

When exchanging either the main board or the expansion board, you must disassemble the module and remove all plug-on assemblies before sending the exchange part. Keep all parts removed in a safe place.

If you are exchanging a main board from a module configured as a 16-channel device, you must remove the expansion board before sending the exchange part.

CAUTION



Almost all electrical components can be damaged by electrostatic discharge (ESD) during handling. Component damage can occur at electrostatic discharge voltages as low as 50 volts. Disassemble and re-configure *only* in a static free work area. Minimize handling of assemblies and components. Keep all assemblies and replacement parts in the original static free packaging.

These procedures should be performed by qualified service personnel at approved static safe workstations.

To Exchange an Assembly

1. Contact the nearest Hewlett-Packard Sales and Service Office for instructions on packaging and shipping.
2. Disassemble the module, using the procedures given in Chapter 6 of this manual, until just the exchange part is obtained. Remove the plug-on modules and expansion board if any.
3. Keep all removed parts in a static-safe place. **Do not send plug-on modules with the exchange assembly. Plug-on modules should be individually replaced, if necessary.**
4. Package the assembly in static-safe packaging material. Shipping guidelines are given on page 18.
5. Include a description of the problem encountered as well as your phone number and return address.

Ordering Information

To order a part listed as an exchange assembly or a part from Table 7-1, 7-2 or 7-3, specify the Hewlett-Packard part number and the quantity desired. Send the order to your nearest Hewlett-Packard Sales and Service Office.

Table 7-1. HP E1418A Exchange/Replaceable Assemblies

Description	Reference Designator	Exchange Part Number	New Part Number
Main board and sheet metal. Does NOT include plug-on assembles or expansion board.	A1	E1418-69201	E1418-66501
Expansion Board. Does NOT include plug-on assemblies.	A2	E1418-69502	E1418-66502
Isolated Plug-On Assembly	PCB1 through PCB16	None	E1418-66503
Non-Isolated plug-On Assembly	PCB1 through PCB16	None	E1418-66504

Table 7-2. HP E1418A Replaceable Parts

Reference Designator	HP Part Number	QTY	Description	Mfr Code	Mfr Part Number
F1001 - 1004	2110-0863	4	Fuse 5A 125V SMT	04703	R459005
HDL1	E1400-45102	1	Hndl-Bottom Metal Injection	28480	E1400-45102
HDL2	E1400-45101	1	Hndl-Top Metal Injection	28480	E1400-45101
MP11	8160-0686	1	Clip-EMC, VXI Module	28480	8160-0686
PCA1	E1418-66501	1	PCA-8CH D/A Converter	28480	E1418-66501
PCA2	E1418-66502	1	PCA-8CH Piggyback	28480	E1418-66502
PCB1-16	E1418-66503	16	PCA-Isolated CH	28480	E1418-66503
	E1418-66504		PCA-NON Isolated CH	28480	E1418-66504
PNL1	E1418-00201	1	Panel Front	28480	E1418-00201
SCR1-8	0515-0372	8	SCR-PANM3x.5TXSC	00000	
SCR1-2	E1400-00610	2	Shoulder Screw Assembly	28480	E1400-00610
SCR3-10	0515-1135	8	SCRFHM3.0x25TX	00000	
SCR14-15	0515-2733	2	SCRPHM2.5 17MM-LG	00000	
SCR16-23	0515-0372	9	SCRPANM3 .5TXSC	00000	
SCR26	0515-1410	1	SCRPHM3.0x20TXSC	00000	
SHD2	E1418-00601	1	SHIELD-TOP	28480	E1418-00601
SHD3	E1418-00604	1	Internal Spacer	28480	E1418-00604
SHD4	E1418-00602	1	SHIELD-BOTTOM	28480	E1418-00602
XJ3001	1258-0141	1	JMPR-REM .025P	28480	1258-0141

Table 7-3. Terminal Module Replaceable Parts

Reference Designator	HP Part Number	QTY	Description	Mfr Code	Mfr Part Number
Terminal Module - Common Parts (see page 91)					
A1	E1400-84405	1	Case Assembly-Term Lexus	24840	E1400-84405
MP1-2	1390-1027	2	Receptical Quick Fastener	24840	1390-1027
MP3	1460-2552	1	Torsion Spring Left Hand	24840	1460-2552
MP4	1460-2553	1	Torsion Spring Right Hand	24840	1460-2553
MP5	E1400-45103	1	Top Lever	24840	E1400-45103
MP6	E1400-45104		Bottom Lever	24840	E1400-45104
Standard Screw Terminal Module (see page 92)					
	E1418-60101	1	Terminal Block Assembly	24840	E1418-60101
JM1-32	1259-0141	32	JMPR-REM .025P	24840	1259-0141
MP11-14	1400-0507	4	Cable Tie Nat Nyl	00000	
PCA1	E1418-66510	1	PCA Terminal Board	24840	E1418-66510
Crimp and Insert Terminal Module Option A3E (see page 92)					
	E1418-60102	1	Terminal Block Asembly	24840	E1418-60102
MP7-10	E1400-21204	4	Crimp & Insert Connector Sup	24840	E1400-21204
P1-2	1252-6532	2	Female Conn Housing Din	24840	1252-6532
SCR1-4	0515-0905	4	SCRPHM2 .5x06PZ	00000	
Ribbon Cable Terminal Module Option A3H (see page 92)					
	E1418-60103	1	Term Block Ribbon Cable	24840	E1418-60103
MP7-10	E1400-21204	4	Crimp & Insert Connector Sup	24840	E1400-21204
MP11-14	1400-0507	4	Cable Tie Nat Nyl	00000	
P1-2	1252-6894	2	DIN-IDC 64 CONT CONN	24840	1252-6894
SCR1-4	0515-0905	4	SCRPHM2 .5x06PZ	00000	

Table 7-4. HP E1418A Reference Designators

Reference Designators	
A	Assembly
F	Fuse
HDL	Handle
J	Electrical Connector
JM	Jumper
MP	Miscellaneous Mechanical Part
P	Electrical Connector
PCA	Printed Circuit Assembly
PCB	Printed Circuit Board
PNL	Panel
SCR	Screw
SHD	Shield
XJ	Removable Jumper

Table 7-5. HP E1418A Code List of Manufacturers

Mfr. Code	Manufacturer's Name	Manufacturer's Address	Zip Code
00000	Any suitable supplier may be used		
04703	Little Fuse Inc.	Arcola, IL, U.S.A.	61910
28480	Hewlett-Packard Company - Corporate	Palo Alto, CA, U.S.A.	94304

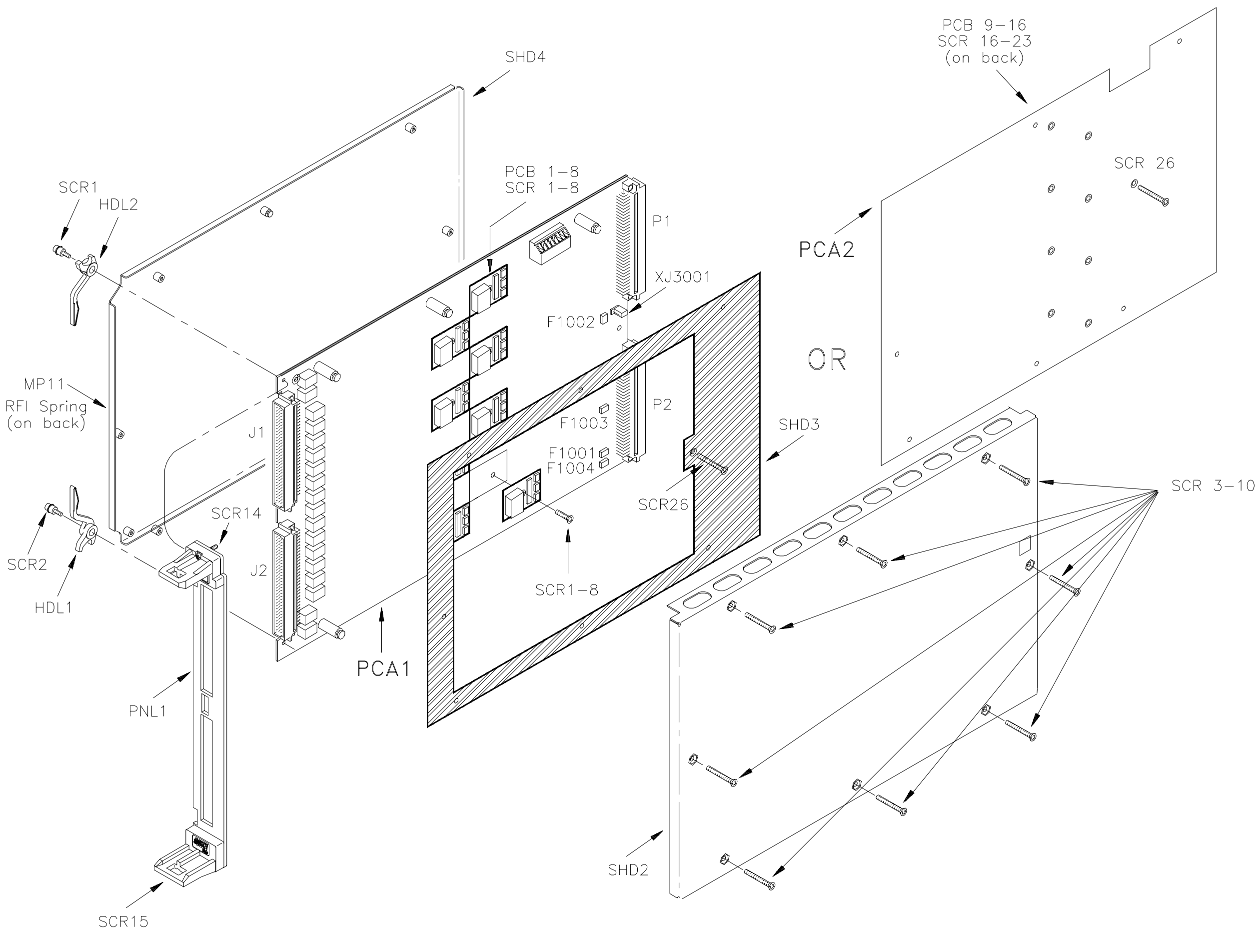


Figure 7-1. HP E1418A Replaceable Parts

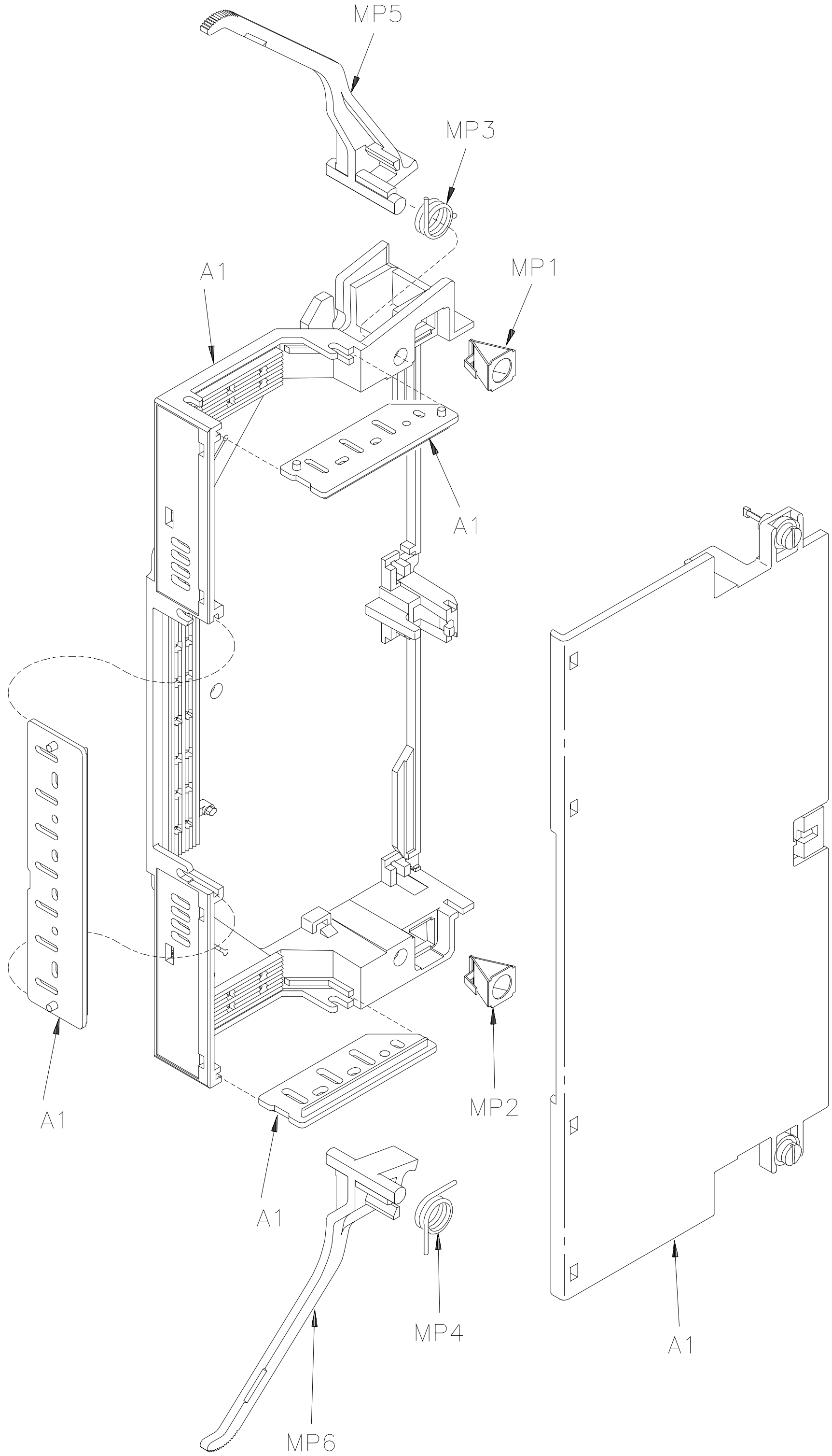


Figure 7-2. Common Terminal Module Replaceable Parts

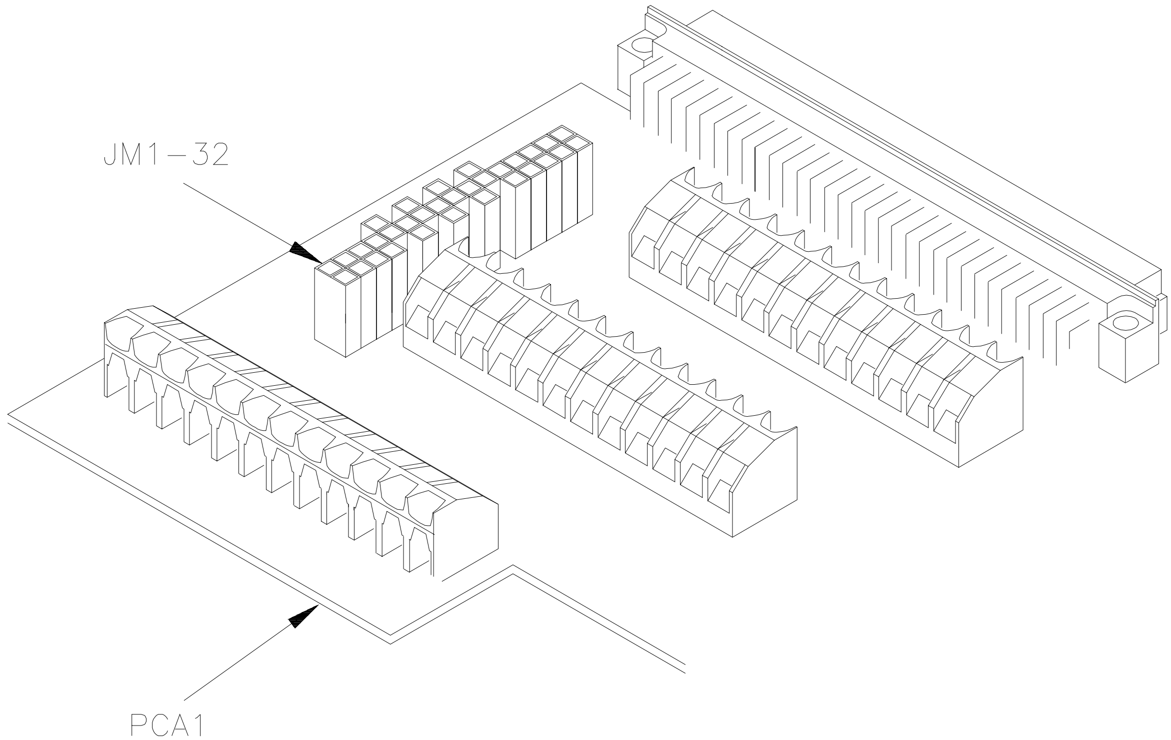


Figure 7-3. Standard Terminal Module Replaceable Parts

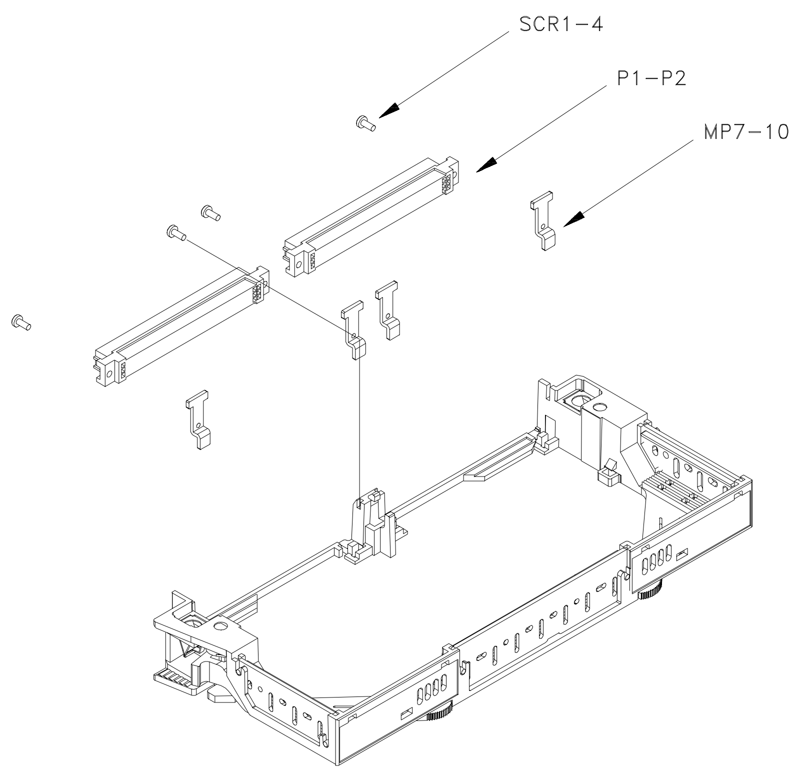


Figure 7-4. Options A3E and A3H Replaceable Parts

Chapter 8
Manual Changes

Introduction

This chapter contains information to adapt this manual to modules for which the content does not directly apply.

This manual applies to all modules. Change information is not required.

Notes

Appendix A
HP E1418A Specifications

DC Voltage

Range:
± 16 V

Resolution:
16 bits (488 µV steps)
Monotonic to 2.0 mV

Accuracy:
± (% of value + volts)
After calibration and at a temperature within ± 5 °C of calibration temperature.
90 day: ± (0.05% + 3.0 mV)

Output Current:
Compliance Current : >20 mA, 0 to ± 12 Volts,
derate linearly to 5 mA at ± 16 Volts
Short Circuit Current: < 60 mA

Differential Ripple and Noise:
< 2 mV rms, 20 Hz to 250 kHz into 10 kΩ load

DC Current

Range:
-0.02 Amps to +0.02 Amps

Resolution:
16 bits (610 nA steps)
Monotonic to 2.5 µA

Accuracy:
± (% of value + amps)
After calibration and at a temperature within ± 5 °C of calibration temperature.
90 day: ± (0.09% + 5.0 µA)

Output Voltage:
Compliance Voltage: ± 12 V
Maximum Open Circuit Voltage: < 18 V

Differential Ripple and Noise:
< 2 µA rms, 20 Hz to 250 kHz into a 250 Ω load

General Characteristics

Settling Time:
300 µS (+ full scale to – full scale step, single channel, to accuracy listed above)

Isolation (isolated channels):
42 Vdc/42 V peak (channel-to-chassis or channel-to-channel)

Synchronization:
Software commands, External TTL trigger, or VXIbus TTL Trigger lines
Single channel or multiple channel

VXI Specification:
Device Type: A16 or A24, D16, slave only, register-based

Power Requirements

	Current Required (Amps)							
Configuration	+5 V DC	+5 V Dynamic	+12 V DC	+12 V Dynamic	+24 V DC	+24 V Dynamic	–24 V DC	–24 V Dynamic
8 Channel Non-Isolated	0.70	0.01	0.04	0.01	0.44	0.01	0.44	0.01
8 Channel Isolated	0.75	0.01	0.04	0.01	0.88	0.01	0.00	0.00
16 Channel Non-Isolated	1.25	0.01	0.04	0.01	0.88	0.01	0.88	0.01
16 Channel Isolated	1.40	0.01	0.04	0.01	1.60	0.01	0.00	0.00

Cooling Requirements

For a 10 °C rise

	Air Flow	∆ P	Avg Watts/slot
8 Channel configurations	2.0 liters/second	0.10 mm H_2O	25.4
16 Channel configurations	3.9 liters/second	0.18 mm H_2O	49.0