Agilent 75000 SERIES C

Agilent E1460A
64-Channel Relay Multiplexer

Service Manual

Enclosed is the Service Manual for the Agilent E1460A 64-Channel Relay Multiplexer Module.

Insert this manual, along with any other VXIbus manuals that you may have, into the binder that came with your Agilent Technologies mainframe or command module.

Agilent Technologies

Manual Part Number: E1460-90012

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Certification

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Agilent E1460A 64-Channel Relay Multiplexer Module Service Manual
Edition 3 Rev 2

Printing History

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

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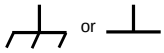
Edition 3 (Part Number E1460-90012). . . . . July 1996

Edition 3 Rev 2 (Part Number E1460-90012) . . . . . August 2006

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.



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

Alternating current (AC).

Direct current (DC).

Indicates hazardous voltages.

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

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

WARNINGS

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

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

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

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

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

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

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

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

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name: Agilent Technologies, Incorporated
Manufacturer's Address: *Measurement Product Generation Unit*
815 14th ST. S.W.
Loveland, CO 80537 USA

Declares, that the product

Product Name: 64 Channel Relay Multiplexer
Model Number: E1460A
Product Options: *This declaration covers all options of the above product(s).*

Conforms with the following European Directives:

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

Conforms with the following product standards:

EMC	Standard	Limit
	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	
	CISPR 11:1997 +A1:1997 / EN 55011:1998	*Group 1 Class A [1]*
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995	*4kV CD, 8kV AD*
	IEC 61000-4-3:1995 / EN 61000-4-3:1995	*3 V/m, 80-1000 MHz*
	IEC 61000-4-4:1995 / EN 61000-4-4:1995	*0.5kV signal lines, 1kV power lines*
	IEC 61000-4-5:1995 / EN 61000-4-5:1995	*0.5 kV line-line, 1 kV line-ground*
	IEC 61000-4-6:1996 / EN 61000-4-6:1996	*3V, 0.15-80 MHz*
	IEC 61000-4-11:1994 / EN 61000-4-11:1994	*I cycle, 100%*
	Canada: ICES-001:1998	
	Australia/New Zealand: AS/NZS 2064.1	
Safety	*IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995*	
	Canada: CSA C22.2 No. 1010.1:1992	
	UL 3111-1:1994	

Supplemental Information:

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

September 5, 2000
Date

Jim White
Name

Quality Manager
Title

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

Notes

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Notes

Chapter 1
General Information

Introduction

This manual contains information required to test, troubleshoot, and repair the Agilent E1460A relay multiplexer module (see Figure 1-1).

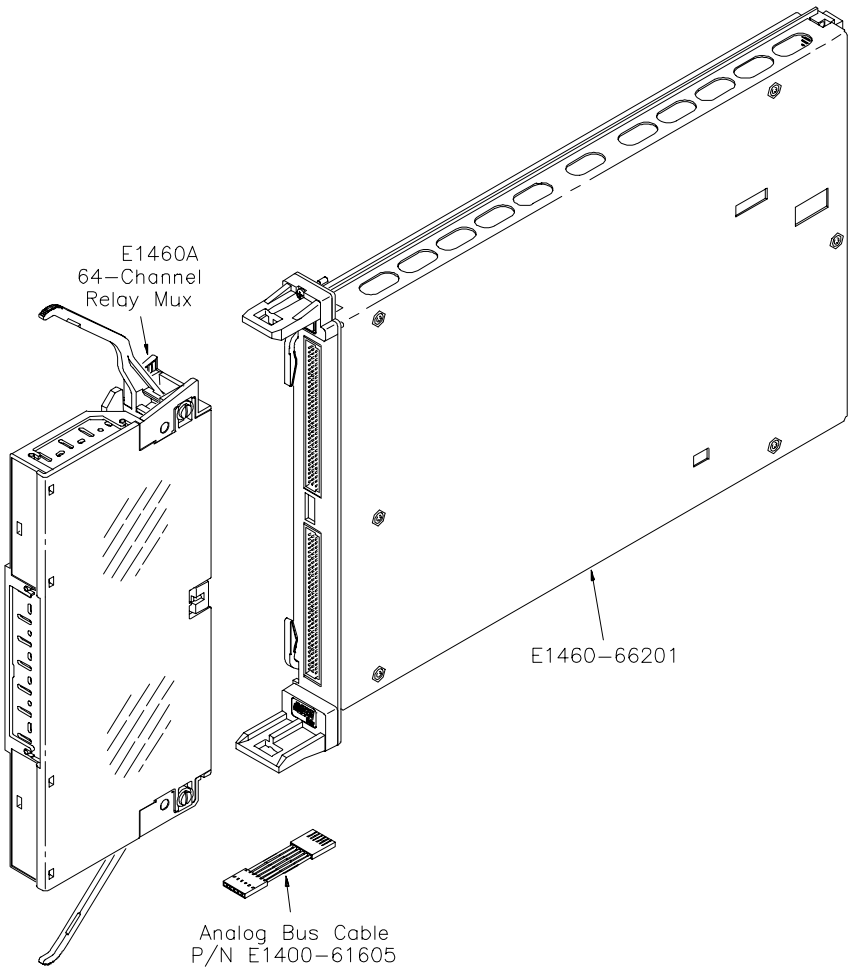


Figure 1-1. Agilent E1460A Relay Multiplexer Module

Relay Life

Electromechanical relays are subject to normal wear-out. Relay life depends on several factors. The effects of loading and switching frequency are briefly discussed below:

Relay Load. In general, higher power switching reduces relay life. In addition, capacitive/inductive loads and high inrush currents (e.g., when turning on a lamp or motor) reduce relay life. ***Exceeding the specified maximum inputs can cause catastrophic failure.***

Switching Frequency. Relay contacts heat up when switched. As the switching frequency increases, the contacts have less time to dissipate heat. The resulting increase in contact temperature reduces relay life.

End-of-Life Detection

A preventive maintenance routine can prevent problems caused by unexpected relay failure. The end of the life of a relay can be determined using one or more of the three methods described below. The best method (or combination of methods), as well as the failure criteria, depends on the application in which the relay is used.

Contact Resistance. As the relay begins to wear out, its contact resistance will increase. When the resistance exceeds a pre-determined value, the relay should be replaced. The end-of-life resistance recommended by Agilent Technologies can be found in Appendix A of the *Agilent E1460A User's Manual.*

Stability of Contact Resistance. The stability of the contact resistance decreases with age. Using this method, the contact resistance is measured several (5-10) times, and the variance of the measurements is determined. An increase in the variance indicates deteriorating performance.

Number of Operations. Alternatively, relays can be replaced after a predetermined number of contact closures. However, this method requires knowledge of the applied load and life specifications for the applied load.

Replacement Strategy

The replacement strategy also depends on the application. If some relays are used more often, or at higher load, than the others, the relays can be individually replaced as needed. If all of the relays see similar loads and switching frequencies, the entire circuit board can be replaced when the end of life approaches. The sensitivity of the application should be weighed against the cost of replacing relays with some useful life remaining.

Note

Relays that wear out normally or fail due to misuse should not be considered defective and are not covered by the product's warranty.

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 4) in this manual for a summary of safety information. Safety information for testing and service follows and is also found throughout this manual.

Warnings and Cautions

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

WARNING

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

CHECK MAINFRAME POWER SETTINGS. Before applying power, verify that the mainframe setting matches the line voltage and that the correct fuse is installed. An uninterruptible safety earth ground must be provided from the main power source to the supplied power cord set. Note: the Agilent E1401A mainframe automatically selects the correct line frequency.

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, and so on). 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 multiplexer. Before you remove any installed module, disconnect AC power from the mainframe and from other modules that may be connected to the multiplexer.

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 INPUTS. The maximum voltage that can be applied to any terminal is 220Vdc/250Vrms. The maximum current that can be applied to any terminal is 1 A at <30Vdc/Vrms, or 0.3 A at <220Vdc/250Vrms. The maximum power that can be applied to any terminal is 40 VA.

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

Incoming Inspection

Use the following steps as guidelines to perform initial (incoming) inspection of the Agilent E1460A.

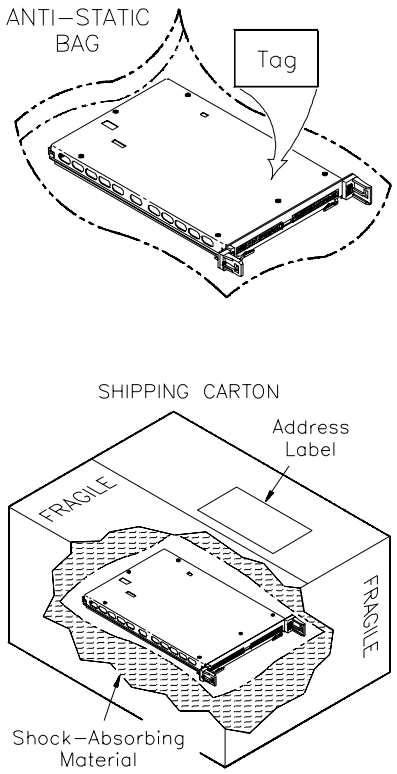
WARNING

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

1. If the Agilent E1460A is damaged, contact Agilent Technologies and contact the carrier.
2. Install the Agilent E1460A in a VXI mainframe. Refer to the *Agilent E1460A Users's Manual* and the *Agilent Series C Installation and Getting Started Guide* for additional information.
3. Perform the Functional Verification test and (optionally) the Performance Verification tests. Refer to Chapter 2 in this manual.
4. If any of the tests do not pass, return the module to Agilent Technologies. See *Shipping Guidelines* later n this chapter.
5. If all verification tests pass, the module is ready to use.

Shipping Guidelines

Follow the steps in Figure 1-2 to return the relay multiplexer module to an Agilent Technologies Sales and Support Office or Service Center.



1 Prepare the module

- Remove any user wiring.
- Attach tag to device that identifies:
  - Owner
  - Model Number/Serial Number
  - Service Required
- Place tagged device in approved anti-static bag.

2 Package the module

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

3 Ship the module to Agilent Technologies

- Place address label on shipping carton.
- Send carton to Agilent Technologies.

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

Figure 1-2. Packaging/Shipping Guidelines

Environment

The recommended operating environment for the multiplexer is:

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

Multiplexer Description

The Agilent E1460A 64-channel relay multiplexer module is an "instrument" in the slot of a VXIbus mainframe. Each module is assigned an error queue, input and output buffers, and a status register.

Note

Instruments are based on the logical addresses of the plug-in modules. See the Agilent 75000 Series C Installation and Getting Started Guide to set the addresses to create an instrument.

Multiplexer Specifications

Specifications are listed in Appendix A of the *Agilent E1460A User's Manual*. These specifications are the performance standards or limits against which the module may be tested.

Multiplexer Serial Numbers

Devices covered by this manual are identified by a serial number prefix listed on the title page. Agilent Technologies uses a two-part serial number in the form XXXXAYYYYY, where XXXX is the serial prefix, A is the country of origin (A=U.S.A.), 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.

Multiplexer Options

There are no electrical or mechanical options available for the 64-channel relay multiplexer module.

Schematics/ Component Locators

Component locators and schematics for the module are included in this manual.

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 is described in the Requirements column.

Table 1-1. Recommended Test Equipment

Instrument	Requirements	Recommended Model	Use*
Controller, GPIB	GPIB compatibility as defined by IEEE Standard 488-1988 and the identical ANSI Standard MC1.1: SH1, AH1, T2, TE0, L2, LE0, SR0, RL0, PP0, DC0, DT0, and C1, 2, 3, 4, 5.	HP 9000 Series 300 or IBM Compatible PC with BASIC	F,O, P,T
Mainframe	Compatible with relay multiplexer	E1401B/T E1421B	F,O, P,T
Command Module	Compatible with relay multiplexer	E1405A/B E1406A	F,O, P,T
Digital Multimeter	4-wire ohms 2-wire ohms (up to 1 GΩ)	Agilent 3458A or Agilent 34401A	O,P,T

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

Chapter 2
Verification Tests

Introduction

The two levels of test procedures described in this chapter are used to verify that the relay multiplexer module:

- is fully functional (Functional Verification);
- meets all testable specifications (Performance Verification).

Test Conditions/ Procedures

See Table 1-1 for test equipment requirements. You should complete the Performance Verification tests at least once a year. For heavy use or severe operating environments, perform the tests more often. It is assumed that the temperature is no greater than 25^{o}C and the relative humidity is no greater than 40%.

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

Performance Test Record

The results of each Performance Verification test may be recorded in the Performance Test Record (Table 2-1). You can make a copy of this form, if desired.

Verification Test Examples

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

- controller is an HP 9000 Series 200/300 computer;
- programming language is BASIC;
- switch address is 70914;
- switch card number is 1;
- DMM is an Agilent 3458A.

Test Fixture

A test fixture is required for the Performance Verification tests. A test fixture can be manufactured from the Agilent E1460A terminal block. It is recommended that you order an extra terminal block to use as a test fixture, so that you do not have to re-wire the terminal block each time these tests are performed. The terminal block part number is E1460-80001. Figure 2-1 shows how the test fixture should be wired.

Note

If you are using an Agilent E1460A terminal block, and some or all of the relay module jumpers have been removed, you should add the following connections to the test fixture shown in Figure 2-1:

1. *Wire all Common High lines together.*
2. *Wire all Common Low lines together.*

These steps are not necessary if all of the relay card jumpers are in place.

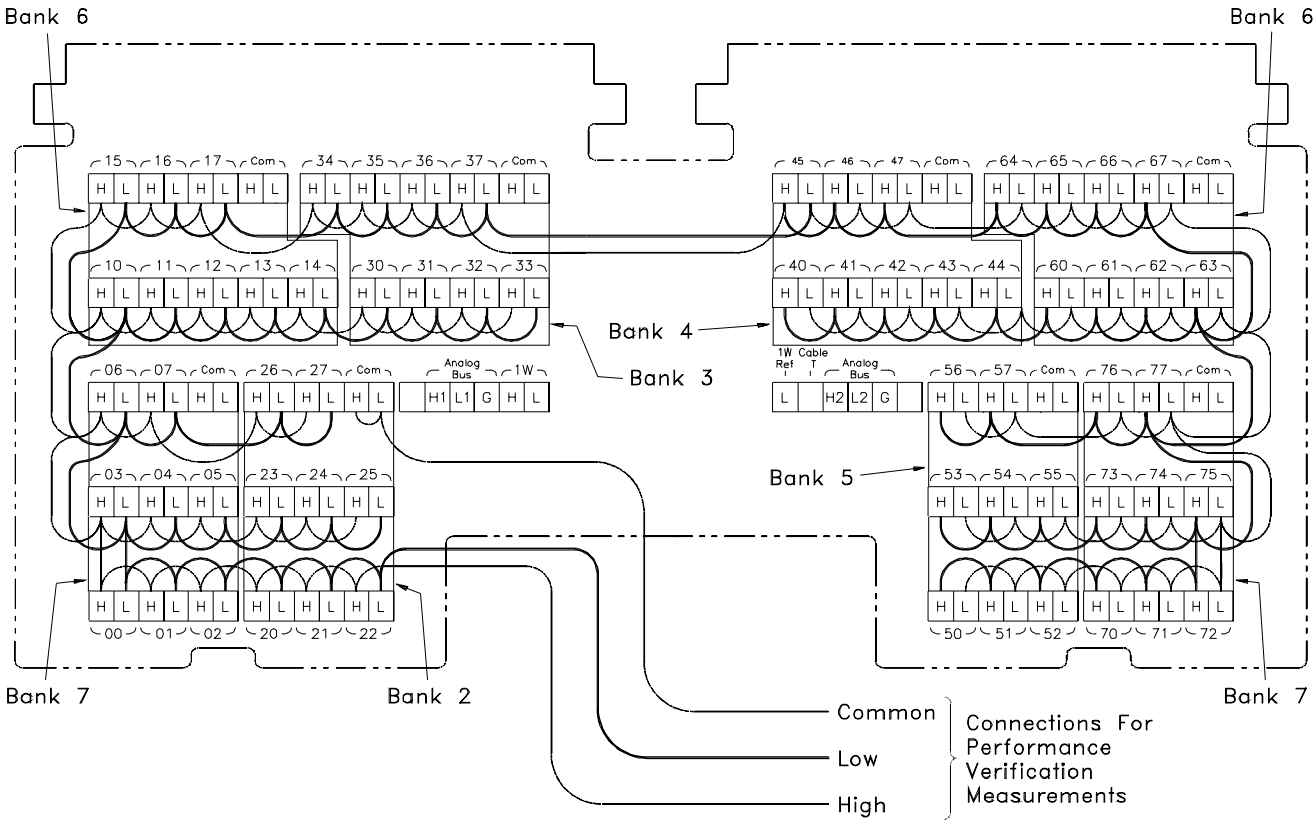


Figure 2-1. Agilent E1460A Test Fixture

Functional Verification

The Functional Verification Test for the relay multiplexer module consists of sending the *TST? command and checking the response. This test can be used at any time to verify that the device is connected properly and is responding to basic commands.

Procedure

1. Verify that the relay multiplexer is installed in the mainframe and that the mainframe has passed its power-on test.
2. Send the *TST? command to the device (see example following).
3. The device will return an error code. Any non-zero error code indicates a self-test failure. See Table 4-5 for a description of self-test error codes.

Example

An example follows which uses an HP 9000 Series 300 computer with BASIC and a multiplexer address of 70914.

```
10   DIM A$[50]
20   OUTPUT 70914;"*RST;*IDN?"          !Module identification
30   ENTER 70914;A$
40   PRINT A$
50   OUTPUT 70914;"SYST:CDES? 1"        !Module Description
60   ENTER 70914;A$
70   PRINT A$
80   OUTPUT 70914;"SYST:CTYP? 1"        !Module Type
90   ENTER 70914;A$
100  PRINT A$
110  OUTPUT 70914;"*TST?"               !Send the self-test command.
120  ENTER 70914;A                      !Get response.
130  PRINT A
140  END
```

A typical response is:

```
HEWLETT-PACKARD,SWITCHBOX,0,A.04.00
64-CHANNEL RELAY MULTIPLEXER
HEWLETT-PACKARD,E1460A,0,A.04.00
+0
```

Self-test Error Codes

Table 2-1 shows the self-test error codes for the multiplexer module. The meaning of each code is given in the right-hand column. If a self-test failure occurs, cycle power and repeat the test. If the problem reoccurs, the device may need repair.

Table 2-1. Self-test Error Codes

Error*	Description
+0	Self-test passes.
+ss01	Firmware error.
+ss02	Bus error (communications problem with card).
+ss03	Bad ID information in ID register.
+ss10	Interrupt expected but not received.
+ss11	Busy bit was not held ≈9 to 17 msec.,

*ss = card number (with leading zero deleted)

Agilent E1460A Performance Verification

The procedures in this section are used to test the multiplexer's electrical performance using the specifications in Appendix A of the *Agilent E1460A User's Manual* as the performance standards. These tests are suitable for incoming inspection, troubleshooting, and preventive maintenance.

Note

In the following procedures, **ss** *represents the switch card number (01-99) of the multiplexer. A leading zero may be omitted.*

Test 2-1: Closed-channel Resistance Test

The purpose of this test is to verify that all channel relay contacts meet the closed-channel resistance specification for the multiplexer. If the closed-channel resistance of any contact is greater than 3.5Ω, the relay should be replaced.

High Lines Test

1. Hardware Connections

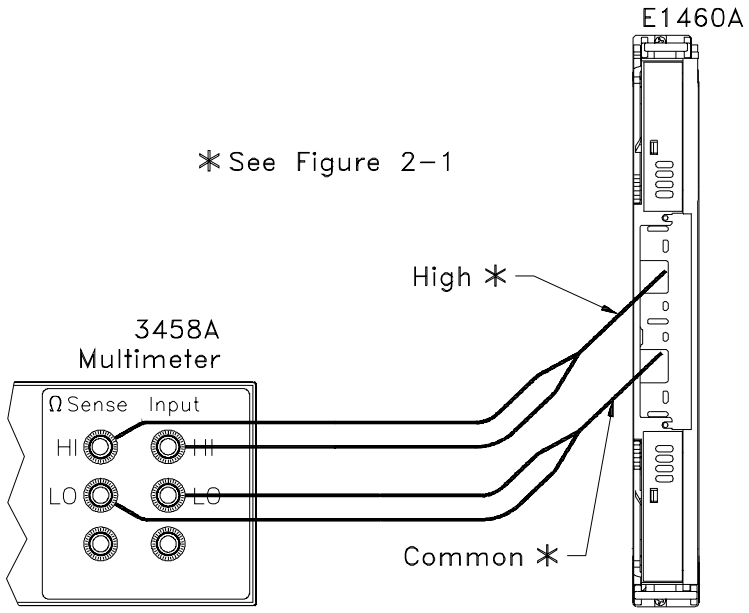


Figure 2-2. Closed-channel Resistance (High Lines)

2. Equipment Setup

- Set DMM to: 4-wire ohms, autorange.
- Send ***RST** to the multiplexer.
- Send **FUNC ss, WIRE2** to the multiplexer to set it to two-wire mode.
- Send **CLOS (@ss0995)** to the multiplexer to connect the lower and upper Common buses together.

3. Closed-channel Reading (channel 00)

   - Send **CLOS (@ss00)** to the multiplexer to close bank 0, channel 0.
   - Trigger the DMM and record the reading.

4. Open-channel Reading (channel 00)

   - Send **OPEN (@ss00)** to the multiplexer to open bank 0, channel 0.
   - Trigger the DMM and verify that an open circuit is indicated (**>**500 MΩ).

5. Closed- and Open-channel Readings (channels 01-77)

   - Repeat steps 3 and 4 for all 64 channels listed in the Performance Test Record for the Agilent E1460A (Table 2-1). Use **CLOS (@ssbc)** and **OPEN (@ssbc)**, where
     ss = card number (01-99, leading zero not necessary)
     b = bank number (0-7)
     c = channel number (0-7)

Low Lines Test

6. Hardware Connections

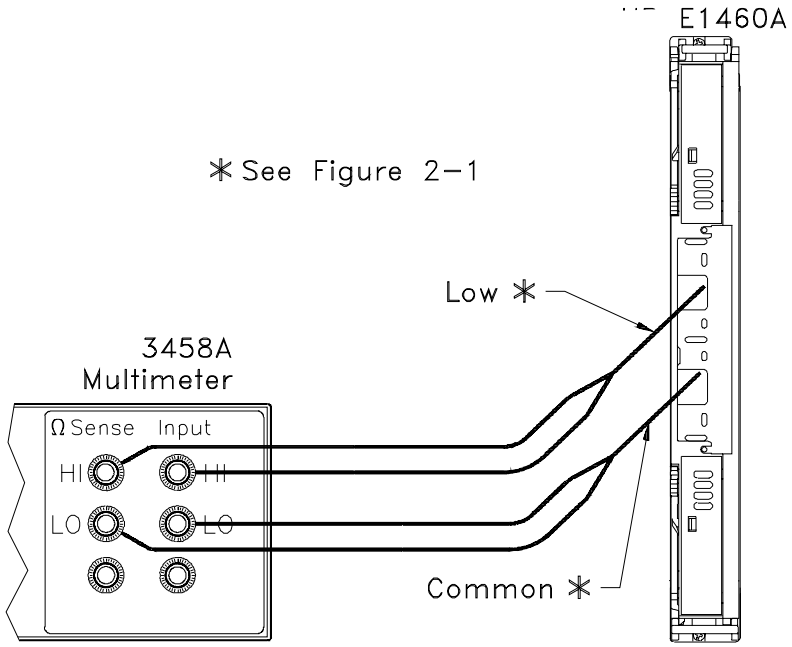


Figure 2-3. Closed-channel Resistance (Low Lines)

7. Repeat steps 1 through 5.

Example: Closed-channel Resistance Test

This example performs the Closed-channel Resistance Test for the Agilent E1460A. If the switch card number is not 1, change the value in line 40 to the correct number. This example can be used to test the High or Low lines of the module.

```
10 !   RE-STORE "CCR_1460"
20     ASSIGN @Mux TO 70914
30     ASSIGN @Dmm TO 722
40     Sw_card=1
50     !
60     OUTPUT @Dmm;"PRESET NORM;TRIG HOLD"      !Set DMM to 4-wire
70     OUTPUT @Dmm;"FUNC OHMF;RANGE AUTO"       !ohms, autorange
80     !
90     OUTPUT @Mux;"*RST"                         !Reset Mux
100    OUTPUT @Mux;"FUNC "&VAL$(Sw_card)&",WIRE2"!Set to 2-wire mode
110    OUTPUT @Mux;"CLOS (@"&VAL$(Sw_card)&"0995)"!Close relay 0995
120    WAIT 1
130    !
140    PRINT "CHANNEL","CLOSED","OPEN"
150    PRINT
160    !
170    FOR I=0 TO 7
180      FOR J=0 TO 7
190        Channel$=VAL$(Sw_card*100+10*I+J)
200        OUTPUT @Mux;"CLOS (@"&Channel$&")"      !Close relay
210        OUTPUT @Dmm;"TRIG SGL"                    !Trigger DMM
220        ENTER @Dmm;Rdg
230        PRINT Channel$,VAL$(DROUND(Rdg,4)),
240        !
250        OUTPUT @Mux;"OPEN (@"&Channel$&")"      !Open relay
260        OUTPUT @Dmm;"TRIG SGL"                    !Trigger DMM
270        ENTER @Dmm;Rdg
280        PRINT VAL$(DROUND(Rdg,4))
290      NEXT J
300    NEXT I
310    !
320    !
330    OUTPUT @Dmm;"RESET"
340    LOCAL @Dmm
350    OUTPUT @Mux;"*RST"
360    END
```

Test 2-2. Testing Control Relays

The E1460-66201 relay module has seven control relays (numbered 0990 to 0996). See the *Agilent E1460A User's Manual* for information about the use of these relays.

There is no simple method for testing all of these control relays, and they are unlikely to wear out under normal use. However, if you need to test one or more of these relays, use Table 2-2 and Figure 2-4 to measure the resistance across the contact(s) in question. Table 2-2 shows the channel numbers, the reference designators, and the recommended test connections to check each relay. The SCPI commands to open and close each contact are given in the right-hand columns.

The DMM can be used in two-wire mode for a functional check, or in four-wire mode for a more accurate measurement. Use the following procedure to check one or more control relays.

Test Procedure

1. Connect the DMM as specified in Table 2-2 (see Figure 2-4).
2. Close the contact to be tested using the SCPI command given in Table 2-2.
3. Trigger the DMM and verify that the resistance is low (less than 3.5 Ω).
4. Open the contact using the SCPI command given in Table 2-2.
5. Trigger the DMM and verify that an open circuit is indicated (>500 MΩ).

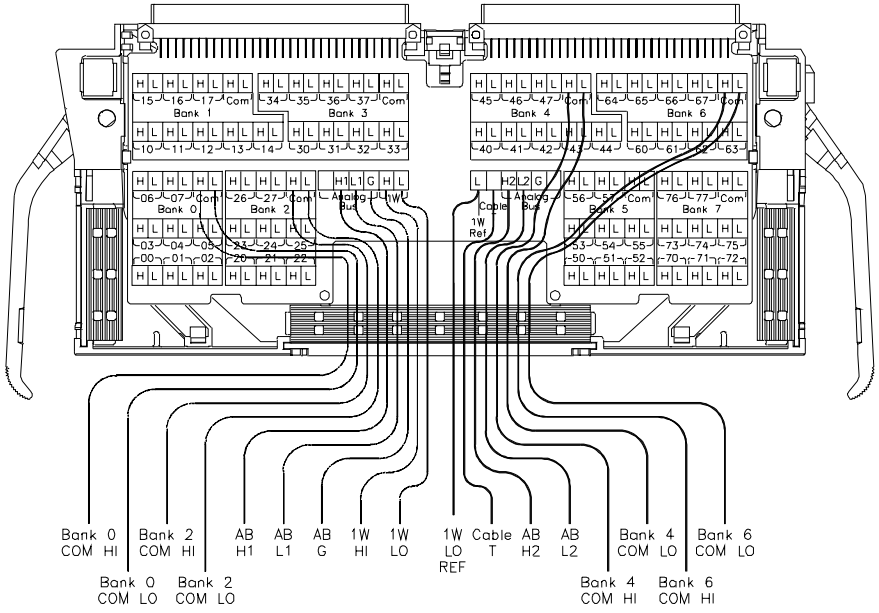


Figure 2-4. Agilent E1460A Control Relay Test Connections

Table 2-2. Guidelines for Testing Control Relays

Control Relay*			Test Connections**		SCPI Commands***	
Channel		Reference Designator	DMM HI	DMM LO	To Close Contact	To Open Contact
0990	-NC	K1	1W HI	Bank 0 COM HI	OPEN (@ss0990)	CLOS (@ss0990)
	-NO		1W HI	Bank 0 COM LO	CLOS (@ss0990)	OPEN (@ss0990)
0991	-NC	K2	1W LO	CABLE T	OPEN (@ss0991)	CLOS (@ss0991)
	-NO		1W LO	1W LO REF	CLOS (@ss0991)	OPEN (@ss0991)
0992	-HI	K3	AB H1	1W HI	CLOS (@ss0992)	OPEN (@ss0992)
	-LO		AB L1	1W LO	CLOS (@ss0992)	OPEN (@ss0992)
0993	-HI	K6	AB H2	Bank 6 COM HI	CLOS (@ss0993)	OPEN (@ss0993)
	-LO		AB L2	Bank 6 COM LO	CLOS (@ss0993)	OPEN (@ss0993)
0994	-HI	K4	AB H2	AB H1	CLOS (@ss0994)	OPEN (@ss0994)
	-LO		AB L2	AB L1	CLOS (@ss0994)	OPEN (@ss0994)
0995	-HI	K7	Bank 2 COM HI	Bank 4 COM HI	CLOS (@ss0995)	OPEN (@ss0995)
	-LO		Bank 2 COM LO	Bank 4 COM LO	CLOS (@ss0995)	OPEN (@ss0995)
0996		K5	AB G (Guard)	Bank 6 COM LO	CLOS (@ss0996)	OPEN (@ss0996)

* NO = normally open contact, NC = normally closed contact
** AB = analog bus, 1W = 1 wire
*** ss = switch card number (leading zero may be omitted)

Example: Control Relay Test

This example program tests the tree relays on the Agilent E1460A relay multiplexer module. If the switch card number is not 1, change the value in line 50 to the correct number.

```
10   DIM MESSAGE$[256]
20   ASSIGN @Mux TO 70914
30   ASSIGN @Dvm TO 722
40   CLEAR SCREEN
50   Sw_card=1
60   OUTPUT @Mux;"*RST"
70   OUTPUT @Mux;"FUNC "&VAL$(Sw_card)&",WIRE2"
80   ! GOSUB Check
90   OUTPUT @Dvm;"PRESET NORM;TRIG HOLD"
100  OUTPUT @Dvm;"FUNC OHMF;RANGE AUTO"
110  DIM CHAN_DATA$(13,4)[15]
120  DATA "NC ","1W HI","BANK 0 COM HI","NO ","1W HI","BANK 0 COM LO"
130  DATA "NC ","1W LO","CABLE T","NO ","1W LO","1W LO REF"
140  DATA "HI ","AB H1","1W HI","LO ","AB L1","1W LO"
150  DATA "HI ","AB H2","BANK 6 COM HI","LO ","AB L2","BANK 6 COM LO"
160  DATA "HI ","AB H2","AB H1","LO ","AB L2","AB L1"
170  DATA "HI ","BANK 2 COM HI","BANK 4 COM HI","LO ","BANK 2 COM
LO","BANK 4 COM LO"
```

```
180   DATA "","AB GUARD","BANK 6 COM LO"
190   FOR I=1 TO 13
200   FOR J=1 TO 3
210   READ Chan_data$(I,J)
220   NEXT J
230   NEXT I
240   !
250   CLEAR SCREEN
260   PRINT
270   I=1
280   FOR Chan_num=990 TO 991
290   !
300   PRINT "Testing channel ";Chan_num;" ";Chan_data$(I,1)
310   PRINT TAB(5);"Connect dvm HI to ;"Chan_data$(I,2);" and dvm LO to
";Chan_data$(I,3)
320   GOSUB Open_ch
330   PRINT
340   I=I+1
350   PRINT "Testing  channel ";Chan_num;" ";Chan_data$(I,1)
360   PRINT TAB(5);"Connect dvm HI to ;"Chan_data$(I,2);" and dvm LO to
";Chan_data$(I,3)
370   GOSUB Close_ch
380   PRINT
390   I=I+1
400   NEXT Chan_num
410   FOR Chan_num=992 TO 995 STEP 1
420   PRINT  "Testing  channel ";Chan_num;" ";Chan_data$(I,1)
430   PRINT TAB(5);"Connect dvm HI to ;"Chan_data$(I,2);" and dvm LO to
";Chan_data$(I,3)
440   GOSUB Close_ch
450   PRINT
460   I=I+1
470   PRINT  "Testing  channel ";Chan_num;" ";Chan_data$(I,1)
480   PRINT TAB(5);"Connect dvm HI to ;"Chan_data$(I,2);" and dvm LO to
";Chan_data$(I,3)
490   GOSUB Close_ch
500   PRINT
510   I=I+1
520   NEXT Chan_num
530   !
540   PRINT
550   Chan_num = 996
560   PRINT  "Testing  channel ";Chan_num
570   PRINT TAB(5);"Connect dvm HI to ;"Chan_data$(I,2);" and dvm LO to
";Chan_data$(I,3)
```

```
580   GOSUB Close_ch
590   PRINT
600   PRINT "END OF TESTS"
610   CLEAR SCREEN
620   I=990
630   FOR J=1 TO 12 STEP 2
640   PRINT "Channel: ";I;Chan_data$(J,1);Chan_data$(J,4);" Ohms"
650   PRINT TAB(15);Chan_data$(J+1,1);Chan_data$(J+1,4);" Ohms"
660   PRINT
670   I=I+1
680   NEXT J
690   PRINT "Channel: 996";TAB(18);Chan_data$(13,4);" Ohms"
700   STOP
710   !
720   !
730   Open_ch:  !
740             PRINT TAB(5);Press 'CONTINUE' when ready"
750             PAUSE
760             Channel$=VAL$(Sw_card*10)&VAL$(Chan_num)
770             OUTPUT @Mux;"OPEN (@"&Channel$&")"
780             GOSUB Read_ch
790             OUTPUT @Mux;"CLOS (@"&Channel$&")"
800             RETURN
810   Close_ch: !
820             PRINT TAB(5);Press 'CONTINUE' when ready"
830             PAUSE
840             Channel$=VAL$(Sw_card*10)&VAL$(Chan_num)
850             OUTPUT @Mux;"CLOS (@"&Channel$&")"
860             GOSUB Read_ch
870             OUTPUT @Mux;"OPEN@"&Channel$&")"
880             RETURN
890   Read_ch:  !
900             OUTPUT @Dvm;"TRIG SGL"
910             ENTER @Dvm;Rdg
920             PRINT TAB(5);Channel ";Chan_num;" measures ";
VAL$(DROUND(Rdg,4))
930             Chan_data$(I,4)=VAL$(Rdg)
940   RETURN
950   Check:    !
960             REPEAT
970             OUTPUT @Mux;"SYST:ERR?"
980             ENTER @Mux;Code,Message$
990             PRINT Code,Message$
1000            UNTIL NOT Code
1010            RETURN
1020  END
```

Test 2-3: DC Isolation Test

This test verifies that sufficient DC isolation exists between various points on the relay multiplexer. The DMM used should be capable of measuring up to at least 1 GΩ. If the DMM indicates an overload, record the reading as ">R_{max}", where R_{max} is the highest resistance that the DMM can measure. If the DMM is an Agilent 3458A, for example, the reading should be written as ">1.2 GΩ".

High to Low

1. Hardware Connections

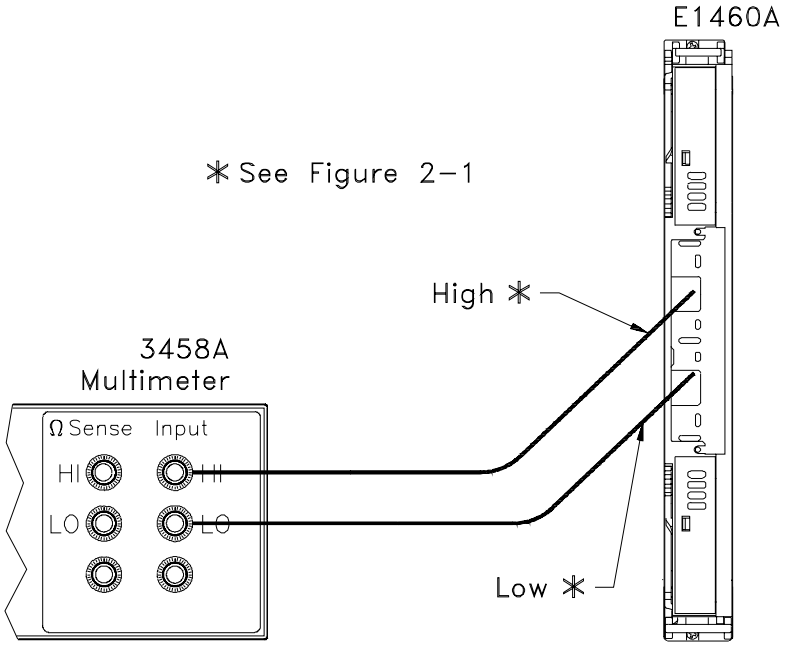


Figure 2-5. High to Low Isolation

2. Equipment Setup

   - Set DMM to: 2-wire ohms, 1 GΩ range.
   - Send ***RST** to the multiplexer to open all channel relay contacts.

3. DC Isolation Reading

   - Trigger the DMM and record the reading.

High & Low to Chassis

4. Hardware Connections

Note

Use any convenient chassis connection. The illustration shows the DMM LO terminal connected to the outside of the Trig Out BNC on the E1406 Command Module.

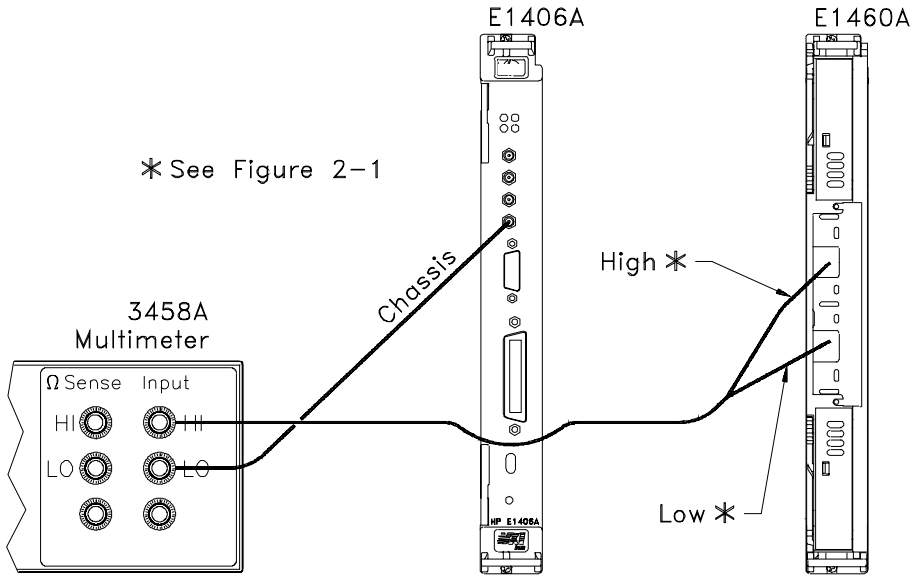


Figure 2-6. High & Low to Chassis Isolation

5. Equipment Setup

   - Send **CLOS (@ss00:ss77)** to the multiplexer to close all channel relays.

6. DC Isolation Reading

   - Trigger the DMM and record the reading.

Example: DC Isolation Test

This example performs the DC Isolation Test for the Agilent E1460A. If the switch card number is not 1, change the value in line 40 to the correct number.

```
10 !   RE-STORE "DC_1460"
20     ASSIGN @Mux TO 70914
30     ASSIGN @Dmm TO 722
40     Sw_card=1
50     First=Sw_card*100                          !First channel
60     Last=First+77                              !Last channel
70     !
80     OUTPUT @Dmm;"PRESET NORM;TRIG HOLD" !Set DMM to 2-wire
90     OUTPUT @Dmm;"FUNC OHM;RANGE 1E9"       !ohms, 1G range
100    !
110    OUTPUT @Mux;"*RST"                         !Reset mux
120    WAIT 1
130    !
140    ! / / / / / / / / / /  High to Low Isolation / / / / / / / / /
150    PRINT "Connect DMM HI to High line."
160    PRINT "Connect DMM LO to Low line."
170    PRINT
180    DISP "Press 'Continue'"
190    PAUSE
200    OUTPUT @Dmm;"TRIG SGL"
210    ENTER @Dmm;Rdg
220    PRINT "DC Isolation -- High to Low = ";Rdg
230    PRINT
240    !
250    ! / / / / / / / / / /  High & Low to Chassis Isolation / / / / / / / / /
260    PRINT "Connect DMM HI to High and Low lines."
270    PRINT "Connect DMM LO to Chassis."
280    PRINT
290    DISP "Press 'Continue'"
300    PAUSE
310    !Close all channel relays
320    OUTPUT @Mux;"CLOS (@"&VAL$(First)&":"&VAL$(Last)&")"
330    WAIT 1
340    OUTPUT @Dmm;"TRIG SGL"
350    ENTER @Dmm;Rdg
360    PRINT "DC Isolation -- High and Low lines to Chassis = ";Rdg
370    PRINT
380    !
390    OUTPUT @Dmm;"RESET"
400    LOCAL @Dmm
410    OUTPUT @Mux;"*RST"
420    END
```

Performance Test Record

Table 2-3 is a form you can copy and use to record performance verification test results for the relay multiplexer. Information concerning test limits, measurement uncertainty, and test accuracy ratio (TAR) is provided below.

Test Limits

Test limits are defined for closed-channel contact resistance and DC isolation using the specifications in Appendix A of the *Agilent E1460A User's Manual*. The closed-channel resistance and DC isolation specifications are single-sided, (i.e., there is an upper limit or a lower limit, but not both). In the Performance Test Record, either the Minimum or Maximum column will be blank.

Measurement Uncertainty

For the performance verification tests in this manual, the measurement uncertainties are based on 90-day accuracy specifications for the Agilent 3458A Digital Multimeter. The calculations are shown below.

Closed-channel Resistance Test

Conditions:

- 4-wire ohms function
- 10 Ω range
- 90-day specifications
- Worst-case reading = 3.5 Ω

$$\begin{aligned} \text{M.U.} &= (15\textit{ppm of Reading} + 5\textit{ppm of Range}) \\ &= (15\times10^{-6} \cdot 3.5 + 5\times10^{-6} \cdot 10) \quad (\Omega) \\ &= \underline{1.03\times10^{-4}\ \Omega} \end{aligned}$$

DC Isolation Test

Conditions:

- 2-wire ohms function
- 1 GΩ range
- 90-day specifications
- Worst-case reading = 1.2 GΩ (highest resistance that can be measured with the Agilent 3458A)

$$\begin{aligned} \text{M.U.} &= (0.5\%\ \textit{of Reading} + 10\textit{ppm of Range}) \\ &= (0.005 \cdot 1.2\times10^{9} + 10\times10^{-6} \cdot 1\times10^{9}) \quad (\Omega) \\ &= \underline{6\times10^{6}\ \Omega} \end{aligned}$$

Test Accuracy Ratio (TAR)

Test Accuracy Ratios are not defined for single-sided measurements, so all closed-channel resistance and DC isolation measurements have 'NA' (Not Applicable) in the TAR column.

Table 2-3. Performance Test Record for the E1460A (Page 1 of 5)

Test Facility:

Name _____ Report No._____

Address_____ Date_____

City/State_____ Customer_____

Phone_____ Tested by_____

Model_____ Ambient temperature_____^{o}C

Serial No._____ Relative humidity_____%

Options_____ Line frequency _____ Hz (nominal)

Firmware Rev._____

Special Notes:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Table 2-3. Performance Test Record for the E1460A (Page 2 of 5)

Model _____ Report No. _____ Date _____

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

Table 2-3. Performance Test Record for the E1460A (Page 3 of 5)

Model _____ Report No. _____ Date_____

Channel*	Minimum**	Low Lines Reading	High Lines Reading	Maximum	Meas Uncert	TAR
Test 2-1. Closed-channel Resistance Test (Values in ohms)						
ss00		_____	_____	3.5	1.03E-4	NA
ss01		_____	_____	3.5	1.03E-4	NA
ss02		_____	_____	3.5	1.03E-4	NA
ss03		_____	_____	3.5	1.03E-4	NA
ss04		_____	_____	3.5	1.03E-4	NA
ss05		_____	_____	3.5	1.03E-4	NA
ss06		_____	_____	3.5	1.03E-4	NA
ss07		_____	_____	3.5	1.03E-4	NA
ss10		_____	_____	3.5	1.03E-4	NA
ss11		_____	_____	3.5	1.03E-4	NA
ss12		_____	_____	3.5	1.03E-4	NA
ss13		_____	_____	3.5	1.03E-4	NA
ss14		_____	_____	3.5	1.03E-4	NA
ss15		_____	_____	3.5	1.03E-4	NA
ss16		_____	_____	3.5	1.03E-4	NA
ss17		_____	_____	3.5	1.03E-4	NA
ss20		_____	_____	3.5	1.03E-4	NA
ss21		_____	_____	3.5	1.03E-4	NA
ss22		_____	_____	3.5	1.03E-4	NA
ss23		_____	_____	3.5	1.03E-4	NA
ss24		_____	_____	3.5	1.03E-4	NA
ss25		_____	_____	3.5	1.03E-4	NA
ss26		_____	_____	3.5	1.03E-4	NA
ss27		_____	_____	3.5	1.03E-4	NA
ss30		_____	_____	3.5	1.03E-4	NA
ss31		_____	_____	3.5	1.03E-4	NA
ss32		_____	_____	3.5	1.03E-4	NA
ss33		_____	_____	3.5	1.03E-4	NA
ss34		_____	_____	3.5	1.03E-4	NA
ss35		_____	_____	3.5	1.03E-4	NA
ss36		_____	_____	3.5	1.03E-4	NA
ss37		_____	_____	3.5	1.03E-4	NA

* ss = switch card number (leading zero may be omitted)
** Single-sided specification -- Minimum does not apply.

Table 2-3. Performance Test Record for the E1460A (Page 4 of 5)

Model _____ Report No. _____ Date_____

Channel*	Minimum**	Low Lines Reading	High Lines Reading	Maximum	Meas Uncert	TAR
Test 2-1. Closed-channel Resistance Test (Values in ohms)						
ss40		_____	_____	3.5	1.03E-4	NA
ss41		_____	_____	3.5	1.03E-4	NA
ss42		_____	_____	3.5	1.03E-4	NA
ss43		_____	_____	3.5	1.03E-4	NA
ss44		_____	_____	3.5	1.03E-4	NA
ss45		_____	_____	3.5	1.03E-4	NA
ss46		_____	_____	3.5	1.03E-4	NA
ss47		_____	_____	3.5	1.03E-4	NA
ss50		_____	_____	3.5	1.03E-4	NA
ss51		_____	_____	3.5	1.03E-4	NA
ss52		_____	_____	3.5	1.03E-4	NA
ss53		_____	_____	3.5	1.03E-4	NA
ss54		_____	_____	3.5	1.03E-4	NA
ss55		_____	_____	3.5	1.03E-4	NA
ss56		_____	_____	3.5	1.03E-4	NA
ss57		_____	_____	3.5	1.03E-4	NA
ss60		_____	_____	3.5	1.03E-4	NA
ss61		_____	_____	3.5	1.03E-4	NA
ss62		_____	_____	3.5	1.03E-4	NA
ss63		_____	_____	3.5	1.03E-4	NA
ss64		_____	_____	3.5	1.03E-4	NA
ss65		_____	_____	3.5	1.03E-4	NA
ss66		_____	_____	3.5	1.03E-4	NA
ss67		_____	_____	3.5	1.03E-4	NA
ss70		_____	_____	3.5	1.03E-4	NA
ss71		_____	_____	3.5	1.03E-4	NA
ss72		_____	_____	3.5	1.03E-4	NA
ss73		_____	_____	3.5	1.03E-4	NA
ss74		_____	_____	3.5	1.03E-4	NA
ss75		_____	_____	3.5	1.03E-4	NA
ss76		_____	_____	3.5	1.03E-4	NA
ss77		_____	_____	3.5	1.03E-4	NA

* ss = switch card number (leading zero may be omitted)
** Single-sided specification -- Minimum does not apply.

Table 2-3. Performance Test Record for the E1460A (Page 5 of 5)

Model _____ Report No. _____ Date_____

Channel*	Minimum**	Low Lines Reading	High Lines Reading	Maximum	Meas Uncert	TAR
Test 2-2. Tree Relay Test (Values in ohms)						
ss0990 NC		_____	_____	3.5	1.03E-4	NA
ss0990 NO		_____	_____	3.5	1.03E-4	NA
ss0991 NC		_____	_____	3.5	1.03E-4	NA
ss0991 NO		_____	_____	3.5	1.03E-4	NA
ss0992 HI		_____	_____	3.5	1.03E-4	NA
ss0992 LO		_____	_____	3.5	1.03E-4	NA
ss0993 HI		_____	_____	3.5	1.03E-4	NA
ss0993 LO		_____	_____	3.5	1.03E-4	NA
ss0994 HI		_____	_____	3.5	1.03E-4	NA
ss0994 LO		_____	_____	3.5	1.03E-4	NA
ss0995 HI		_____	_____	3.5	1.03E-4	NA
ss0995 LO		_____	_____	3.5	1.03E-4	NA
ss0996		_____	_____	3.5	1.03E-4	NA

Test Description	Minimum	Reading	Maximum*	Meas Uncert	TAR
Test 2-3. DC Isolation Test (Values in ohms)					
High to Low	5E8	_____		6.0E6	NA
High & Low to Chassis	5E8	_____		6.0E6	NA

* ss = switch card number (leading zero may be omitted)
** Single-sided specification -- Maximum does not apply.

Chapter 3
Replaceable Parts

Introduction

This chapter contains information for ordering replaceable parts for the Agilent E1460A relay multiplexer module.

Ordering Information

To order a part listed in this chapter, specify the Agilent part number and the quantity required. Send the order to your nearest Agilent Technologies Sales and Support Office.

Replaceable Parts List

See the table below for the contents of each table in this chapter. Any applicable illustrations are listed in the right-hand column.

Table	Description	Illustrations
3-1	E1400-80011 terminal module case assembly replaceable parts (serial numbers greater than 3002A03220)	Figure 3-1
3-2	E1400-80001 terminal module case assembly replaceable parts (serial numbers less than 3002A03219)	Figure 3-2
3-3	Agilent E1460A terminal module (E1460-66510)*	Figure 3-3
3-4	Agilent E1460A Option A3E terminal module (E1460-80012)	Figure 3-4
3-5	ME1460A relay module mechanical replaceable parts (serial numbers greater than 3002A03220)	Figure 3-5
3-6	E1460-66201 relay module mechanical replaceable parts (serial numbers less than 3002A03219)	Figure 3-6
3-7	ME1460A component level parts list (PC Assy #E1460-66502)	Drawing Number L-E1460-66502 (component locator)
3-8	Code List of Manufacturers	N.A.
3-9	Reference Designators	N.A.

Table 3-1. E1400-80011 Terminal Module Case Assembly
(for modules with serial numbers greater than 3002A03220)

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
A1	E1400-84405	1	CASE ASSEMBLY-TERMINAL CARD	28480	E1400-84405
MP1-MP2	1390-1027	2	Receptical Quick Fastener	28480	1390-1027
MP3	1460-2552	1	Torsion Spring Left Hand Wound	28480	1460-2552
MP4	1460-2553	1	Torsion Spring Right Hand Wound	28480	1460-2552
MP5	E1400-45103	1	Top Lever	28480	E1400-45103
MP6	E1400-45104	1	Bottom Lever	28480	E1400-45104

Note: The part number for a complete terminal module is E1460-80011.

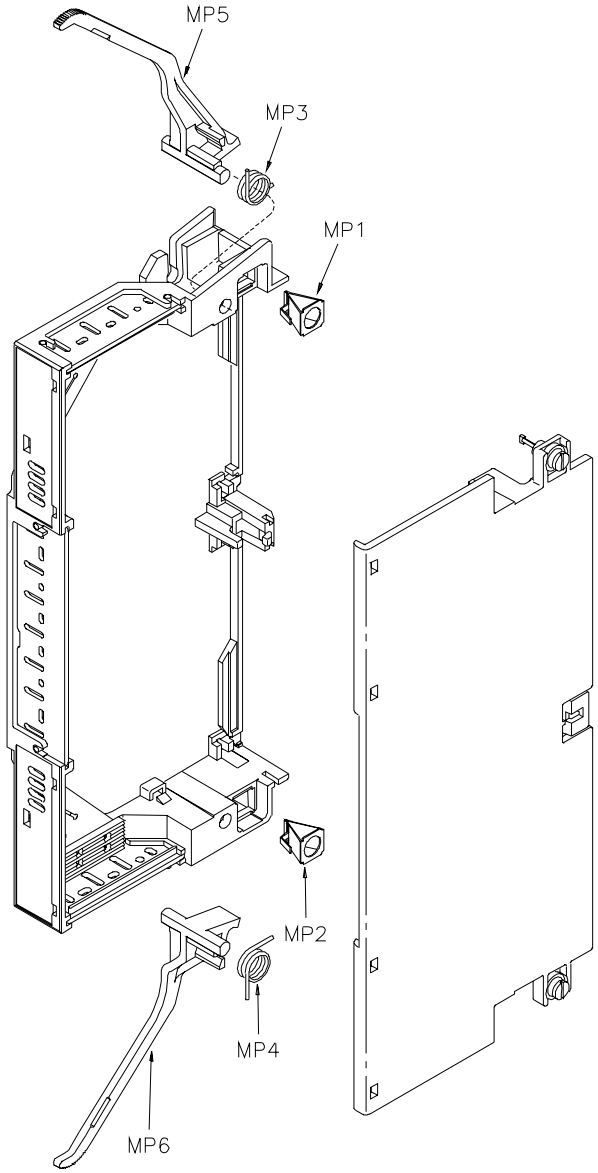


Figure 3-1. E1400-80011 Terminal Module Case Assembly

Table 3-2. E1400-80001 Terminal Module Case Assembly (for modules with serial numbers less than 3002A03219)

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
	E1400-84401	**1**	**CASE, TERMINAL BLOCK ASSEMBLY**	**28480**	**E1400-84401**
1	03852-01201	1	Clamp	28480	03852-01201
2	03852-86701	1	Pad - clamp	28480	03852-86701
3	0515-2109	1	Screw - machine 10-24 .625-in-lg pan-hd-slt	28480	0515-2109
4	1390-0846	2	Fastener - captive screw M2.5 x 0.45	28480	1390-0846
5	E1300-01202	1	Clamp strain relief	28480	E1300-01202
6	E1400-44104	1	Terminal housing - bottom	28480	E1400-44104
7	E1400-44105	1	Terminal housing - top	28480	E1400-44105

Note: The part number for a complete terminal module is E1460-80001.

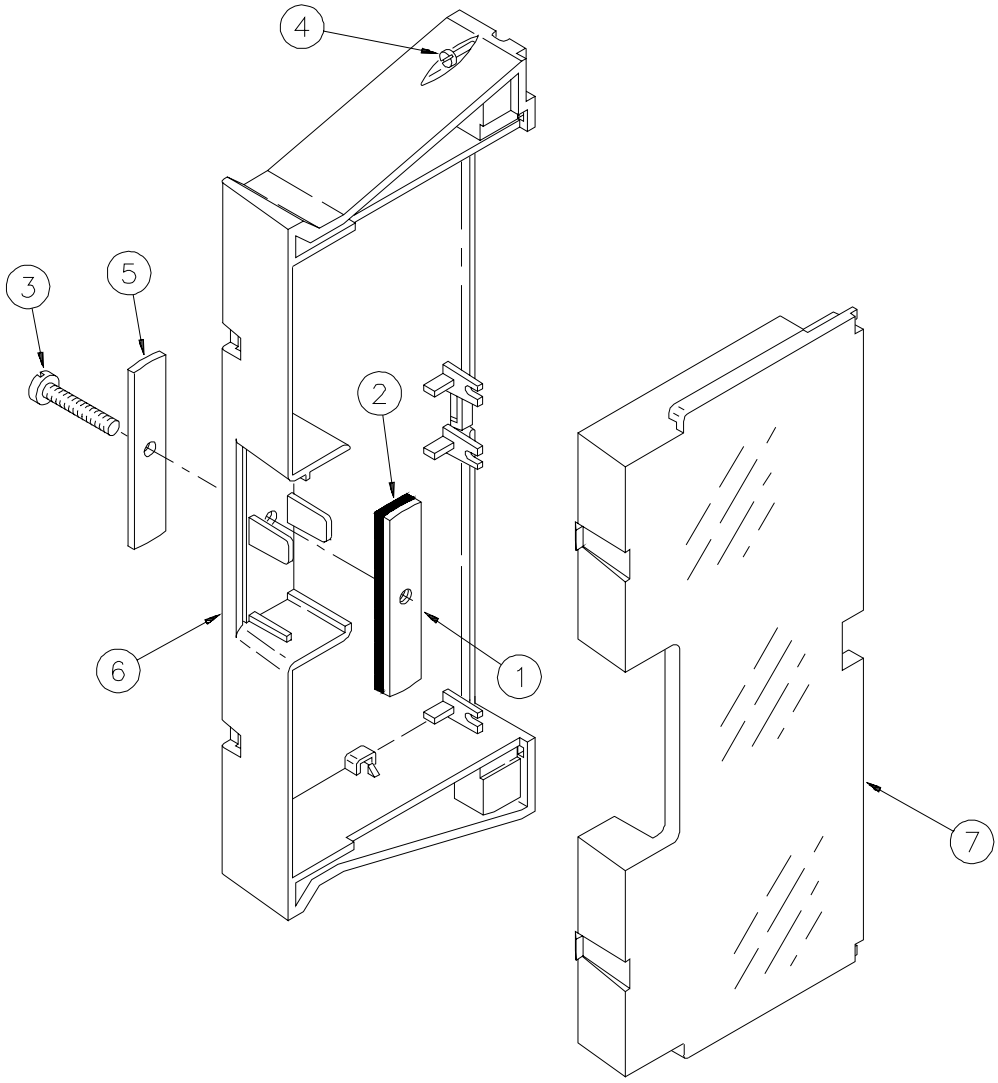


Figure 3-2. E1400-80001 Terminal Module Case Assembly

Table 3-3. E1460A Terminal Module Replaceable Parts

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
	E1460-66510	**1**	**PC ASSEMBLY-TERMINAL CARD**	**28480**	**E1460-66510**
P1-P2	1252-1593	2	Connector-post type 2.54-pin-spcg 96-contact	06776	DIN-96RSC-SR1-TR
TB1-TB2	0360-2391	4	Terminal block 12 pos. polyamide	28480	0360-2391
TB3-TB5	0360-2501	6	Terminal block polyester 10 pos.	30035	BB-125-10
TB6-TB11	0360-2502	6	Terminal block 8 pos. polyester	30035	BB-125-08
TB12-TB13	0360-2391		Terminal block 12 pos. polyamide	28480	0360-2391
TB14-TB16	0360-2501		Terminal block polyester	30035	BB-125-10

Note: The part number for a complete terminal module is E1460-80011 or E1460-80001.

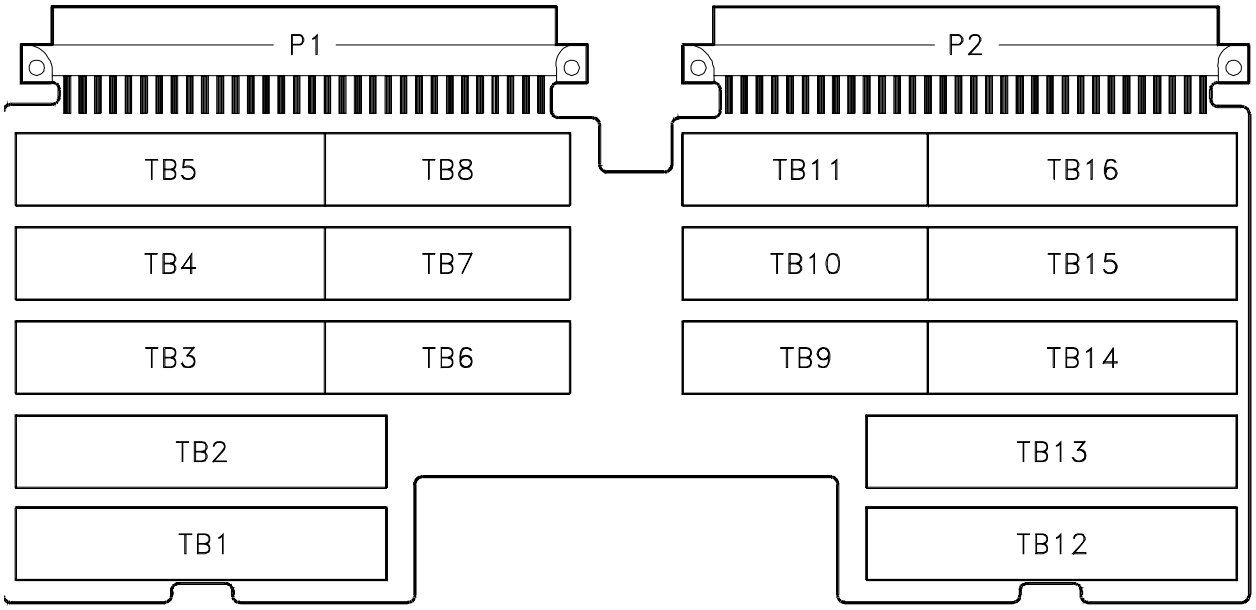


Figure 3-3. E1460A Terminal Module (E1460-66510)

Table 3-4. Agilent E1460A Option A3E Terminal Module Replaceable Parts

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
SCR1-SCR4	0515-0905	4	Screw Pan Head M2.5 x 06PZ	28480	0515-0905
P1-P2	1252-6532	2	Female Connector Housing	28480	1252-6532
MP7-MP10	E1400-21204	4	Crimp & Insert Connector Support	28480	E1400-21204

Note: The part number for a complete terminal module is E1460-80012.

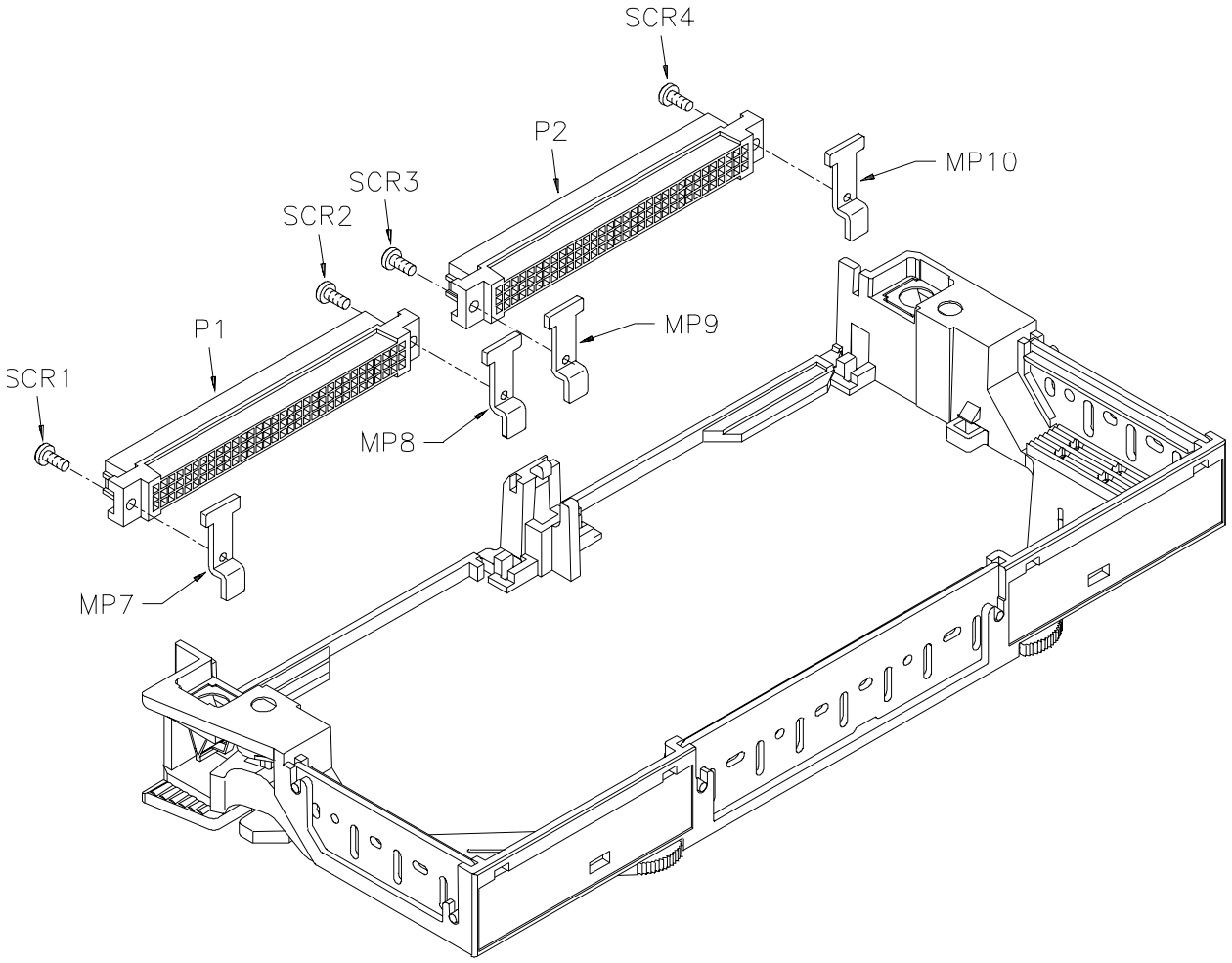


Figure 3-4. E1460A Option A3E Terminal Module

Table 3-5. ME1460A Relay Module Mechanical Replaceable Parts (for modules with serial numbers greater than 3002A03220)

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
	ME1460A	**1**	**MODULE-64 CHANNEL MULTIPLEXER**	**28480**	**ME1460A**
	E1400-61605	1	Ribbon cable assembly (not shown)	28480	E1400-61605
	E1460-90003	1	E1460A User's Manual (not shown)	28480	E1460-90003
A1	E1460-66502	1	Relay Module PC assembly	28480	E1460-66502
MP1	E1400-45102	1	Handle bottom - Metal injection	28480	E1400-45102
MP2	E1400-45101	1	Handle top - Metal injection	28480	E1400-45101
MP3	8160-0686	1	RFI Strip-fingers BE-CU tin-plated	30817	00786-185
PNL1	E1460-00202	1	Front panel	28480	E1460-00202
SCR1-SCR2	E1400-00610	2	Shoulder screw assembly	28480	E1400-00610
SCR3-SCR8	0515-1135	6	Screw-M3 X 0.5 25mm-long flat-hd	28480	0515-1135
SHD1	E1460-00602	1	Shield; bottom shield for multiplexer	28480	E1460-00602
SHD2	E1460-00603	1	Shield; top shield for multiplexer	28480	E1460-00603

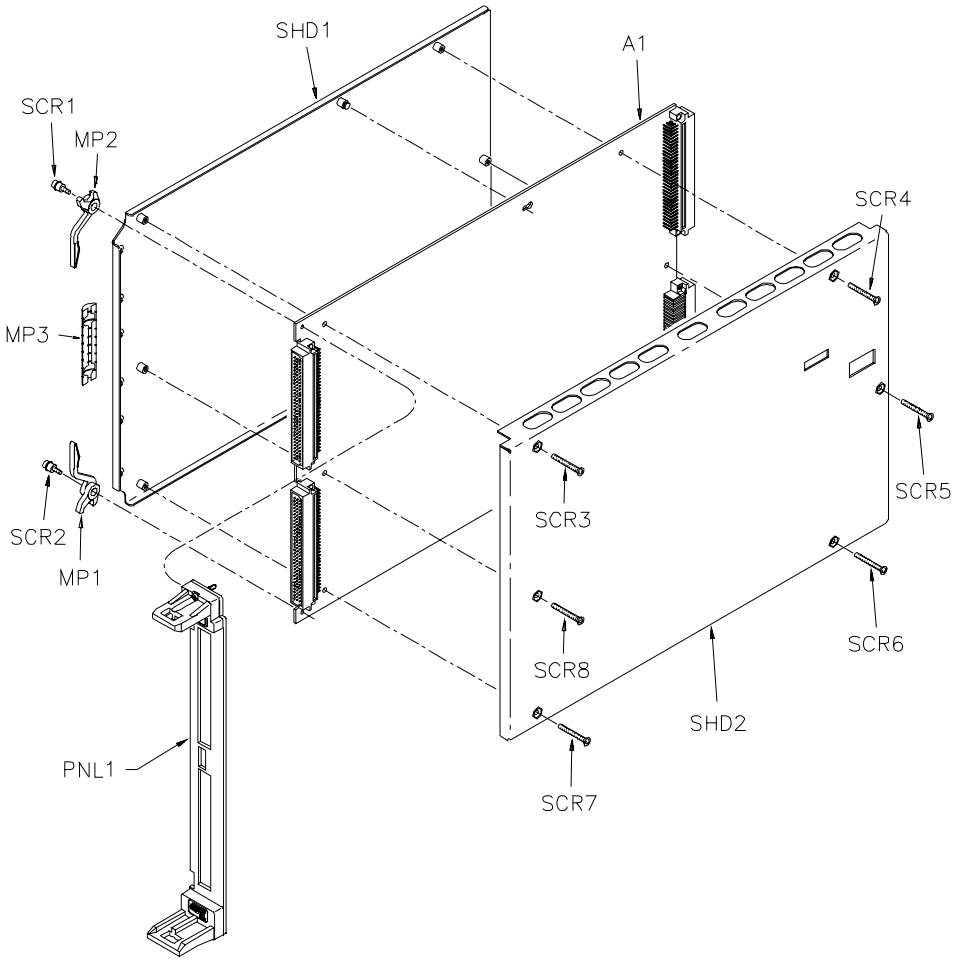


Figure 3-5. ME1460A Relay Module Mechanical Parts

Table 3-6. E1460-66201 Relay Module Mechanical Replaceable Parts (for modules with serial numbers less than 3002A03219)

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
	E1460-66201	**1**	**MODULE-64 CHANNEL MULTIPLEXER**	**28480**	**E1460-66201**
	E1400-61605	1	Ribbon cable assembly (not shown)	28480	E1400-61605
	E1460-90003	1	E1460A User's Manual (not shown)	28480	E1460-90003
A1	E1460-66502	1	Relay Module PC assembly	28480	E1460-66502
MP1	E1400-84105	1	External handle kit-bottom	28480	E1400-84105
MP2	E1400-84106	1	External handle kit-top	28480	E1400-84106
MP3	8160-0686	1	RFI Strip-fingers BE-CU tin-plated	30817	00786-185
PNL1	E1460-00201	1	Front panel	28480	E1460-00201
SCR1-SCR2	0515-0368	2	Screw-M2.5 x 0.45 12mm-long pan-hd	28480	0515-0368
SCR3-SCR8	0515-1135	6	Screw-M3 X 0.5 25mm-long flat-hd	28480	0515-1135
SCR9-SCR10	0515-1375	2	Screw-M2.5 X 0.45 6mm-long flat-hd	83486	343-300-02506
SCR11-SCR12	0515-1968	2	Screw-M2.5 X 0.45 11mm-long pan-hd	28480	0515-1968
SHD1	E1460-00602	1	Shield; bottom shield for multiplexer	28480	E1460-00602
SHD2	E1460-00603	1	Shield; top shield for multiplexer	28480	E1460-00603

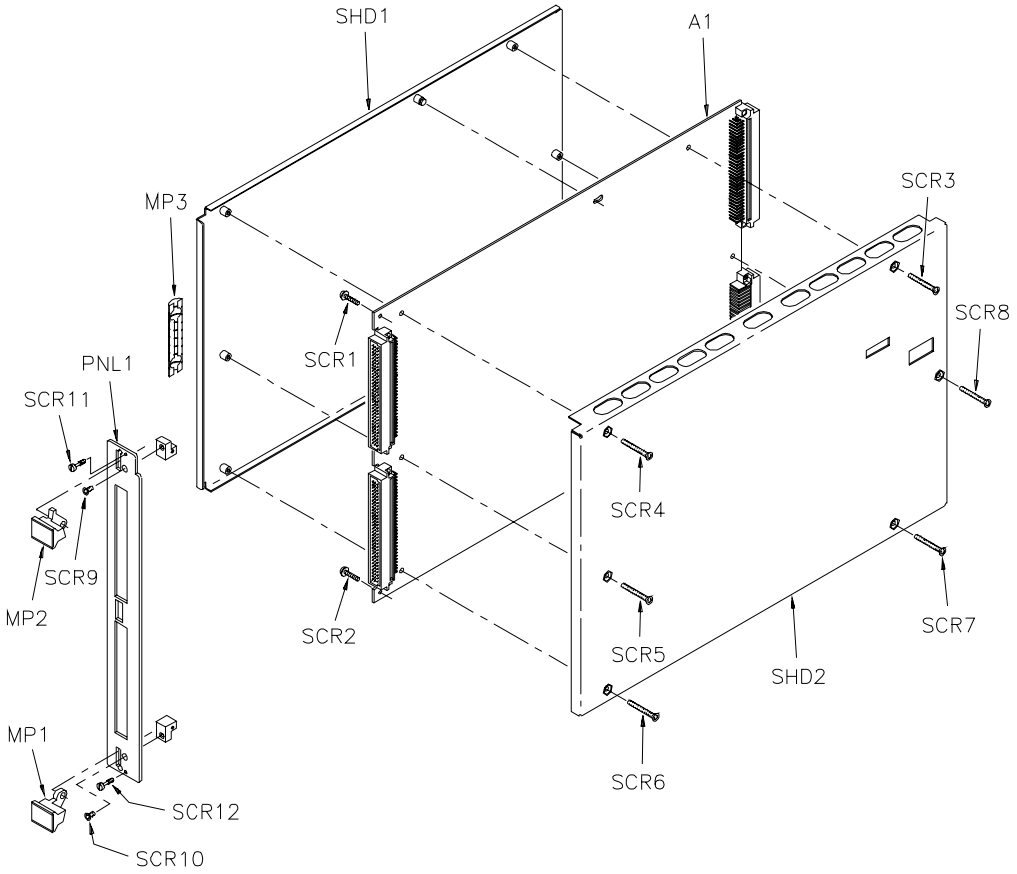


Figure 3-6. E1460-66201 Relay Module Mechanical Parts

Table 3-7. ME1460A Component Level Parts List

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
	E1460-66502	**1**	**MULTIPLEXER PRINTED CIRCUIT ASSY**	**28480**	**E1460-66502**
C1	0160-4801	1	Capacitor-fxd 100pF ±5% 100 V	04222	SA102A101JAAH
C2-C12	0160-4835	16	Capacitor-fxd 0.1µF ±10% 50 V	04222	SA105C104KAAH
C15-C16	0180-1746	2	Capacitor-fxd 15µF ±10% 20 V	56289	150D156X9020B2-DYS
C17	0160-7318	1	Capacitor-fxd 0.22µF ±2% 100 V	28480	0160-7318
C18	0160-4832	5	Capacitor-fxd 0.01µF ±10% 100 V	04222	SA101C103KAAH
C19	0180-0291	1	Capacitor-fxd 1µF ±10% 35 V	56289	150D105X9035A2-DYS
C20	0160-4832		Capacitor-fxd 0.01µF ±10% 100 V	04222	SA101C103KAAH
C21-C25	0160-4835		Capacitor-fxd 0.1µF ±10% 50 V	04222	SA105C104KAAH
C26-C28	0160-4832		Capacitor-fxd 0.01µF ±10% 100 V	04222	SA101C103KAAH
C29-C30	0180-0100	2	Capacitor-fxd 4.7µF ±10% 35 V	56289	150D475X9035B2-DYS
CR1	1901-1098	1	Diode-switching 50V 200MA 4NS	27014	1N4150
CR2	1901-0743	1	Diode-power rectifier 400V 1A DO-41	71744	1N4004
CR3-CR159	1902-0594	157	Diode-zener 18V 5% PD=1W IR=5UA	28480	1902-0594
CR160-CR169	1901-1164	10	Diode-switching 80V 200MA 2NS DO-35	28480	1901-1164
F1-F2	2110-0712	2	Fuse-subminiature 4A 125V NTD AX	75915	R251004T1
J1-J2	1252-1596	2	Connector-post type 2.54-pin-spcg 96-contact	06776	DIN-96CPC-SRI-TR
J3	1252-0776	1	Connector-post type .100-pin-spcg 12-contact	00779	102979-6
J4-J5	1251-4927	2	Connector-post type .100-pin-spcg 16-contact	18873	67997-616
JM1-JM5	7175-0057	13	Resistor 0 MFS	28480	7175-0057
JM10-JM17	7175-0057		Resistor 0 MFS	28480	7175-0057
K1-K7	0490-1912	71	Relay 2C 12VDC-coil 2A 250VAC	28480	0490-1912
K10-K73	0490-1912		Relay 2C 12VDC-coil 2A 250VAC	28480	0490-1912
L1-L2	9140-1354	2	Inductor-fixed 47µH ±15% .453d-in x .9lg-in	91637	IHD-3-01 47 uH 15%
P1	1252-1596	1	Connector-post type 2.54-pin-spcg 96-contact	06776	DIN-96CPC-SRI-TR
P2	1252-4743	1	Connector-post type 2.54-pin-spcg 64-contact	00779	650945-5
Q1-Q3	1854-1028	3	Transistor NPN SI PD=350MW FT=300MHZ	04713	2N3904
Q4-Q12	1855-0567	9	Transistor MOSFET P-Chan E-Mode SI	9M011	IRFD9123
R1	0757-0417	1	Resistor 562 ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-562R-F
R2	0757-0421	1	Resistor 825 ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-825R-F
R3	0698-3228	1	Resistor 49.9K ±1% ⅛W TF TC=0+-100	28480	0698-3228
R4	0757-0465	1	Resistor 100K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-1003-F
R5	0698-0085	1	Resistor 2.61K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-2611-F
R6	0698-3442	1	Resistor 237 ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-237R-F
R7-R8	0757-0442	6	Resistor 10K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-1002-F
R9	0757-0452	1	Resistor 27.4K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-2742-F
R10	0698-4444	1	Resistor 4.87K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-4871-F
R11	0757-0453	1	Resistor 30.1K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-3012-F
R12-15	0757-0442		Resistor 10K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-1002-F
R16-R19	0757-0472	4	Resistor 200K ±1% ⅛W TF TC=0+-100	24546	CT4-1/8-T0-2003-F

(Continued on next page)

Table 3-7. ME1460A Component Level Parts List (continued)

Reference Designator	Agilent Part Number	Qty	Part Description	Mfr. Code	Mfr. Part Number
RP1-RP3	1810-0279	3	Network-resistor 10-Pin 4.7kΩ X 9	56289	256CK472X2PD
RP4-RP6	1810-0265	3	Network-resistor 16-Pin 680.0Ω X 8	32997	4116R-001-681
RP7-RP10	1810-0280	4	Network-resistor 10-Pin 10.0kΩ X 9	01121	210A103
SP1	3101-3066	1	Switch-Dip Rocker 8-1A 0.15A 30VDC	81073	76YY22968S
SP2	3101-2063	1	Switch-Dip Rocker 4-1A 0.05A 30VDC	81073	76YY23444S
U1	1820-6731	1	IC-ASIC GATE-ARRAY CMOS	27014	SCX6B04ACE/N9
U2	1820-3184	1	IC Gate CMOS/HC AND TPL 3-INP	27014	MM74HC11N
U3	1820-4147	1	IC Latch CMOS/HCT Transparent OCTL	34371	CD74HCT573E
U4	1820-4057	1	IC Buffer TTL/F NAND QUAD 2-INP	18324	74F38N
U5-U8	1820-3079	4	IC Decoder CMOS/HC Bin 3-to-8-Line	04713	MC74HC138N
U9-U10	1820-3081	2	IC FF CMOS/HC D-Type Pos-Edge-Trig	04713	MC74HC74N
U11	1820-3146	4	IC FF CMOS/HC D-Type Pos-Edge-Trig COM	04713	MC74HC175N
U12-U14	1820-3975	3	IC Driver CMOS/HC Line OCTL	01295	SN74HC541N
U15	1820-4590	1	IC Multi-Vib CMOS/HC Monostab Retrig Dual	27014	MM74HC423AN
U16-U17	1820-3714	2	IC Transceiver TTL/ALS BUS OCTL	01295	SN74ALS245A-1N
U18-U19	1820-3631	2	IC Comparator CMOS/HCT Magnitude 8-Bit	27014	MM74HCT688N
U20	1820-4242	1	IC Schmitt-Trig CMOS/HCT INV HEX	18324	74HCT14N
U21-U22	1820-4643	2	IC Gate CMOS/HCT NOR QUAD 2-INP	18324	74HCT02N
U23	1820-4586	1	IC Driver/Receiver CMOS/HCT BUS OCTL	01295	SN74HCT541N
U24	1826-0393	1	IC V Regulator-Adj-Pos 1.2/37V TO-220 Pkg	27014	LM317T
U25	1820-3146		IC FF CMOS/HC D-Type Pos-Edge-Trig COM	04713	MC74HC175N
U26	1858-0069	1	Transistor ARRAY 18-Pin	56289	ULN-2803A
U27-U28	1820-3146		IC FF CMOS/HC D-Type Pos-Edge-Trig COM	04713	MC74HC175N
U29-U32	1820-4599	4	IC-Interface Driver Misc/Unknown NAND	56289	UDN-2543B
XJM3	1258-0247	1	Jumper 4-position	22526	69146-204

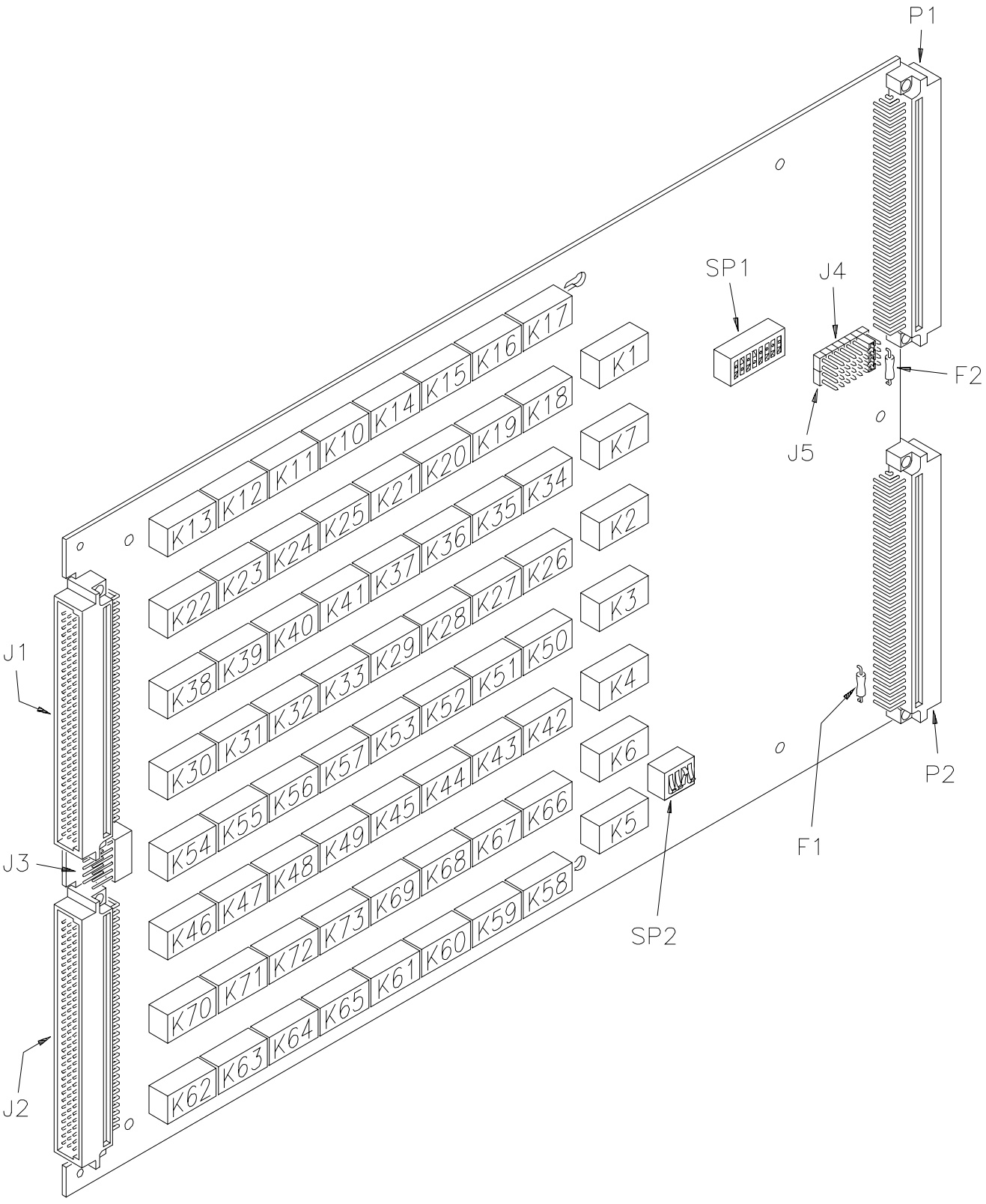


Figure 3-7. Relay Module Component Locator

Table 3-5. Code List of Manufacturer's

Mfr. Code	Manufacturer's Name	Manufacturer's Address	Zip Code
00779	AMP Inc	Harrisburg, PA	17111
01121	Allen-Bradley Co. Inc.	El Paso, TX	79935
01295	Texas Instruments Inc.	Dallas, TX	75265
04222	AVX Corp.	Great Neck, NY	11021
04713	Motorola Inc.	Roselle, IL	60195
06776	Robinson Nugent Inc.	New Albany, IN	47150
18324	Signetics Corp.	Sunnyvale, CA	94086
18873	Dupont E I De Nemours & Co.	Wilmington, DE	19801
22526	Berg Electronics Inc.	Ettersill, PA	17319
24546	Corning Glass Works	Corning, NY	14830
27014	National Semiconductor Corp.	Santa Clara, CA	95052
28480	Agilent Technologies, Inc. - Corporate	Palo Alto, CA	94304
30035	Jolo Industries	Santa Ana, CA	92643
30817	Instrument Specialties Co. Inc.	Del Water Gap, PA	18327
32997	Bourns Networks Inc.	Riverside, CA	92507
34371	Harris Corp.	Melbourne, FL	32901
46384	Penn Engineering & Mfg. Corp.	Doylestown, PA	18901
56289	Sprague Electric Co.	Lexington, MA	02173
71744	General Instrument Corp.	Clifton, NJ	07012
75915	Littelfuse Inc.	Des Plaines, IL	60016
81073	Grayhill Inc.	La Grange, IL	60525
83486	Elco Tool and Screw Corp.	Rockford, IL	61125
91637	Vishay Electronic Components	Columbus, NE	68601
9M011	Intl Rectifier Corp.	Los Angeles, CA	90069

Table 3-6. Agilent E1460A Reference Designators

Reference Designators	
A ..... assembly	P ..... electrical connector (plug)
BRK ..... bracket	PNL ..... panel
C ..... capacitor	Q ..... transistor
CR ..... diode	R ..... resistor
CVR ..... cover	RP ..... resistor pack
F ..... fuse	SCR ..... screw
J ..... electrical connector (jack)	SHD ..... shield
JM ..... jumper	SW ..... switch
K ..... relay	TB ..... terminal block
L.....inductor	U ..... integrated circuit
MP ..... mechanical part	XJM..... removable jumper

Chapter 4
Service

Introduction

This chapter contains service information for the Agilent E1460A 64-Channel Relay Multiplexer module, including troubleshooting techniques and repair/maintenance guidelines.

WARNING

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

Equipment Required

Equipment required for multiplexer/matrix troubleshooting and repair is listed in Table 1-1, *Recommended Test Equipment*. Any equipment that satisfies the requirements given in the table may be substituted. To avoid damage to the screw head slots, use a T8 Torx driver to remove the front panel handles and a T10 Torx driver to remove the shields.

Service Aids

See Chapter 3 for descriptions and locations of Agilent E1460A replaceable parts. Component locators and schematics are included with this manual. Service notes, manual updates, and service literature for the modules may be available through Agilent Technologies. For information, contact your nearest Agilent Technologies Sales and Support Office. A list of Sales and Support Offices can be found at the back of this manual.

Troubleshooting

To troubleshoot an Agilent E1460A multiplexer problem, you should first identify the problem, and then isolate the cause using the component locators and schematics in this manual.

Identifying the Problem

Table 4-1 lists some common problems, along with symptoms and possible solutions. If the problem persists, perform component-level troubleshooting using the component locators and schematics.

Table 4-1. Agilent E1460A Common Problems

Problem Type	Symptom	Possible Solutions
Self-test Errors	Non-zero error code in response to the *TST? command.	• See Table 2-1 for information on self-test errors.
Operator Errors	Non-zero error code in response to the SYST:ERR? command.	• See Appendix C of the *Agilent E1460A User's Manual* for multiplexer errors and causes. • See Appendix B of the *Agilent E1405 User's Manual* or *Agilent E1406 User's Manual* for additional information on operator errors.
Catastrophic Failures	Not responding to commands.	• Check logical address setting. • Check GPIB cables and connections. • See "Testing the Assembly" in this chapter.
Performance Out of Specification	Failing Closed-channel Resistance Test (see Test 2-1 in Chapter 2).	• Check user wiring and test connections. • Replace relays that correspond to the channels that are failing (see Table 4-3). • If most of the channels are near or above the test limit (3.5 Ω), replace the entire printed circuit board (Agilent part number E1460-66502).
	Failing DC Isolation Test (see Test 2-3 in Chapter 2).	• Check user wiring and test connections. • Remove dust from relay module and terminal module printed circuit boards.

Testing the Assembly

You can use the tests and checks in Table 4-2 to isolate the problem. See Figures 3-1 through 3-4 in Chapter 3 for locations of mechanical parts. See the component locator (drawing L-E1460-66502) included with this manual for locations of electrical components.

Table 4-2. Agilent E1460A Tests/Checks

Test/Check	Reference Designator	Check:
Heat Damage	- - - - - - - - - -	Discolored PC boards Damaged insulation Evidence of arcing
Switch Settings	SP1 SP2	LADDR setting IRQ Level setting
Multiplexer PCA	F1, F2 P1, J1 K1, K2, ..., K7 K10, K11, ..., K73	Fuse continuity Connector contacts Relay contact resistance

Checking for Heat Damage

Inspect the assembly for signs of abnormal internally generated heat such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing.

Checking Switches/Jumpers

Verify that the logical address switch is set correctly (factory set at 112). Verify that the interrupt priority jumpers are set correctly (factory set at level 1).

Checking the Multiplexer PCA

Use the component locators in this manual to check the following:

- Verify that fuses F1 and F2 are good.
- Check the closed-channel resistance of all channel relays using the procedure in Chapter 2. Replace any bad relays. Use Table 4-3 to isolate the relay that corresponds to each failing channel.
- Check connectors P1 and J1 for damage.

Note

If the preceding steps fail to isolate the problem, use the schematics in this manual to perform component-level troubleshooting.

Matching Relays to Channels

Use Table 4-3 to find the reference designator of any relay on the E1460-66502 relay module.

Table 4-3. Channel Relays/Reference Designators

E1460A Channel Relay			E1460A Channel Relay		
Bank	**Channel**	**Ref. Designator**	**Bank**	**Channel**	**Ref. Designator**
00	00	K10	04	00	K57
00	01	K11	04	01	K56
00	02	K12	04	02	K55
00	03	K13	04	03	K54
00	04	K14	04	04	K53
00	05	K15	04	05	K52
00	06	K16	04	06	K51
00	07	K17	04	07	K50
01	00	K25	05	00	K49
01	01	K24	05	01	K48
01	02	K23	05	02	K47
01	03	K22	05	03	K46
01	04	K21	05	04	K45
01	05	K20	05	05	K44
01	06	K19	05	06	K43
01	07	K18	05	07	K42
02	00	K41	06	00	K73
02	01	K40	06	01	K72
02	02	K39	06	02	K71
02	03	K38	06	03	K70
02	04	K37	06	04	K69
02	05	K36	06	05	K68
02	06	K35	06	06	K67
02	07	K34	06	07	K66
03	00	K33	07	00	K65
03	01	K32	07	01	K64
03	02	K31	07	02	K63
03	03	K30	07	03	K62
03	04	K29	07	04	K61
03	05	K28	07	05	K60
03	06	K27	07	06	K59
03	07	K26	07	07	K58
Control Relays					
	Channel	**Ref. Designator**		**Channel**	**Ref. Designator**
	0990	K1		0994	K4
	0991	K2		0995	K7
	0992	K3		0996	K5
	0993	K6			

Disassembly

Use the following procedures to disassemble the ME1460A relay module (see Figure 4-1):

To remove the top shield:

- Remove the six T10 Torx screws as shown.
- Lift the top shield off of the module.

To remove the bottom shield:

- Slide A1 in the direction shown until the retaining pins on the shield align with the larger holes on A1.
- Lift A1 off of the bottom shield.

To remove the front panel and front panel handles:

- Remove the two T8 Torx screws as shown.

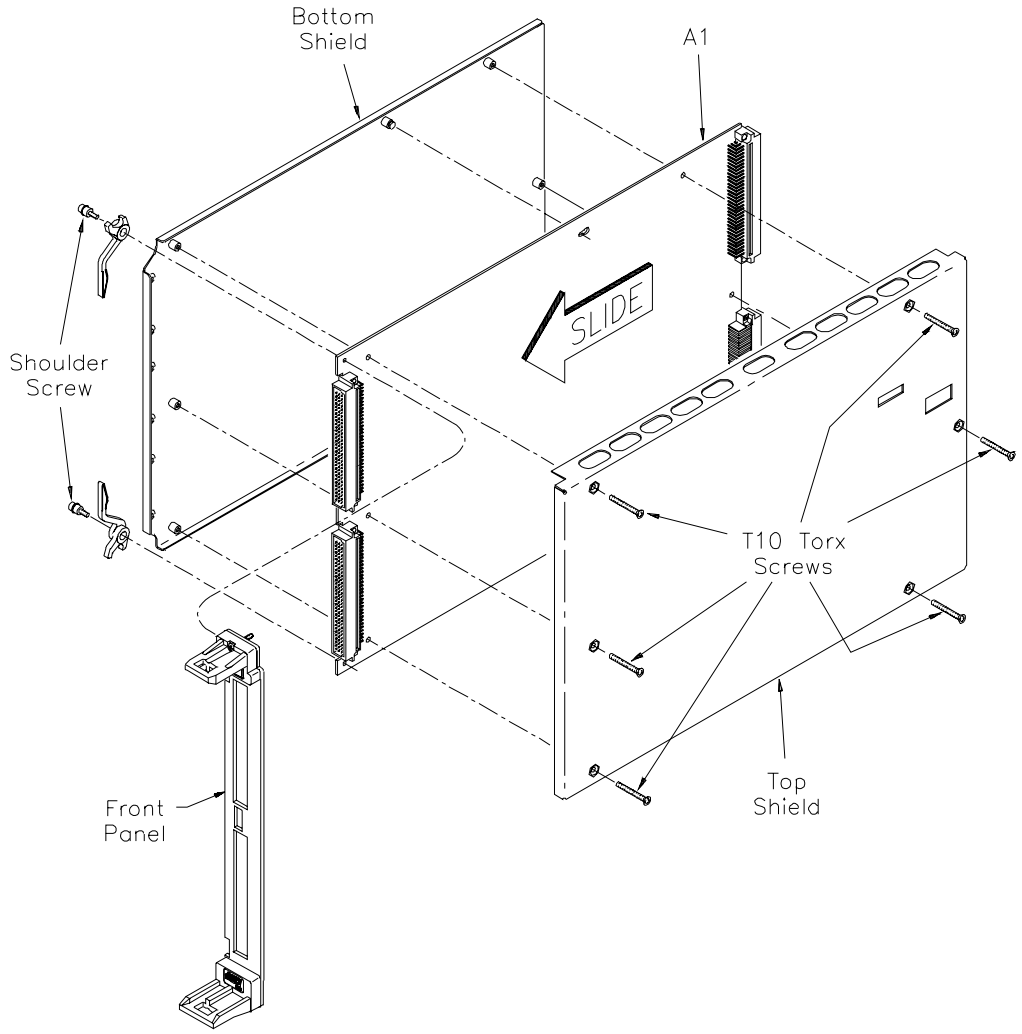


Figure 4-1. ME1460A Relay Module Disassembly

Repair/ Maintenance Guidelines

This section provides guidelines for repairing and maintaining the Agilent E1460A multiplexer module, including:

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

ESD Precautions

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

- Always use a static-free work station with a pad of conductive rubber or similar material when handling electronic components.
- Do not use pliers to remove a MOS or CMOS device from a high-grip socket. Instead, use a small screwdriver to pry the device up from one end. Slowly lift the device up, one pair of pins at a time.
- After you remove a MOS or CMOS device from a module, place the device onto a pad of conductive foam or other suitable holding material.
- If a device requires soldering, be sure the assembly is placed on a pad of conductive material. Also, be sure that you, the pad, and the soldering iron tip are grounded to the assembly.

Soldering Printed Circuit Boards

The etched circuit board in the multiplexer module has plated-through holes that allow a solder path to both sides of the insulating material. Soldering can be done from either side of the board with equally good results. When soldering to any circuit board, keep in mind the following guidelines:

- Do not use a high power soldering iron on etched circuit boards, as excessive heat may lift a conductor or damage the board.
- Use a suction device or wooden toothpick to remove solder from component mounting holes. When using a suction device, be sure that the equipment is properly grounded.

Post-Repair Safety Checks

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

Component Locators and Schematic Diagrams

Table 4-4 lists Component Locator Diagrams and Schematic Diagrams for the Agilent E1460A Relay Multiplexer module.

Table 4-4. Component Locators and Schematics Diagrams

	Part Number	Drawing Number	Drawing Title
Component Locator Diagram	E1460-66502	L-E1460-66502	Relay Multiplexer Component Assembly (see Chapter 3 for parts list and component locator)
Schematic Diagrams	E1460-66502 E1460-66502 E1460-66502 E1460-66502 E1460-66502 E1460-66502 E1460-66502 E1460-66510	S-E1460-66502(1) S-E1460-66502(2) S-E1460-66502(3) S-E1460-66502(4) S-E1460-66502(5) S-E1460-66502(6) S-E1460-66502(7) S-E1460-66510	Component Assembly - VXI P1,P2 Connectors & Power Component Assembly - VXI Interface Logic Part 1 Component Assembly - VXI Interface Logic Part 2 Component Assembly - Relay Interface & Drive Component Assembly - Analog & Configuration Bus Component Assembly - Channels 00-37 Component Assembly - Channels 40-77 64-Channel Relay Multiplexer Terminal Card

Appendix A
Verification Tests - C Programs

Note

These examples assume a Multiplexer logical address setting of 70914. If your Multiplexer has a different address, see the Agilent E1460A User's Manual to change the logical address or change the program line #define ADDR "hpib7,9,14" *to match your address setting.*

Functional Verification Test

This example is designed to do the Functional Verification Test found in *Chapter 2 - Verification Tests*. The test for the relay multiplexer module consists of sending the *TST? command and checking the response.

```
/* Self Test                                E1460A
   This program performs the Self Test found
   in the E1460A Service Manual
   Program Rev. A.01.00  7/1/96  */

#include <stdio.h>
#include <sicl.h>
#define ADDR "hpib7,9,14"                   /* Address of device */

void main ()
{
   INST id;                                 /* Define id as an instrument */
   char a[256] = {0};                       /* Result variable */
   id = iopen (ADDR);                       /* Open instrument session */

   ipromptf(id, "*RST;*IDN?\n", "%t", a);   /* Self test command */
   printf("\n %s", a);                      /* Print result */

   ipromptf(id, "SYST:CDES? 1\n", "%t", a); /* Module description */
   printf ("\n %s", a);

   ipromptf(id, "SYST:CTYP? 1\n", "%t", a); /* Module type */
   printf ("\n %s", a);

   ipromptf(id, "*TST?\n", "%t", a);        /* Self test */
   printf ("\n %s", a);

   if (a[1] != '0')
   {
      do
      {
         ipromptf (id, "SYST:ERR?\n", "%t", a);
         printf ("\n %s", a);
      }
      while (a[1] != '0');
   }

   iclose (id);                                     /* Close instrument session */
}
```

Performance Verification Tests

These programs are designed to do the Performance Verification Tests found in *Chapter 2 - Verification Tests.*

Test 2-1: Closed Channel Resistance

The purpose of this test is to verify that all channel relay contacts meet the closed channel resistance specification for the multiplexer. If the closed channel resistance of any contact is greater than 3.5Ω, the relay should be replaced. See Chapter 2 for hardware connections and equipment setup.

```
/*  Closed-channel Resistance Test          E1460A
    This program performs the Closed Channel Resistance Test found
    in the E1460A Service Manual
    Program Rev. A.01.00  7/1/96  */

#include <stdio.h>
#include <sicl.h>

#define ADDR "hpib7,9,14"                       /* Address of device */
#define DMM "hpib7,22"

void main (void)
{
    INST id, dm;                                /* Define id and dm as an instrument */
    int channel, i, j;
    double result, result2;
    char cr[256];

    #if defined(__BORLANDC__) && !defined(__WIN32__)
     _InitEasyWin();
    #endif

    ionerror(I_ERROR_EXIT);

    dm = iopen (DMM);                           /* Open instrument session */
    id = iopen(ADDR);

    itimeout (dm, 10000);

    printf ("\n\n\nInstall Component Assembly and Test Fixture");
    printf ("\n\n 1. Turn Mainframe AND hp 3458a DMM power OFF.");
    printf ("\n 2. Connect GPIB Cable between mainframe and DMM.");
    printf ("\n 3. Install Agilent E1460A Component Assembly into Mainframe.");
    printf ("\n 4. Attach Test Fixture to Component Assembly.");
    printf ("\n 5. Turn Mainframe and DMM power ON");
    printf ("\n 6. Press ENTER when ready to begin testing.");
    getchar ();

    /*.........................Measure Closed Channel Resistance.....*/

    iprintf (id, "*RST\n");
    iprintf (id, "FUNC 1,WIRE2\n");
    iprintf (id, "CLOS(@10995)\n");
    iprintf (dm, "PRESET NORM;TRIG HOLD\n");
    iprintf (dm, "END ALWAYS\n");
    iprintf (dm, "FUNC OHMF\n");

    /*.......................High lines.....................*/
```

```
    printf ("\n\nHigh to Common Measurements");
    printf ("\n\n 1. Connect DMM Input HI lead to High lines");
    printf ("\n 2. Connect DMM Input LO lead to Common lines");
    printf ("\n 3. Press ENTER when connections are complete");
    getchar ();

    for (i = 0;i <= 7; i++)
      for (j = 0;j <= 7; j++)
      {
        iprintf (id, "CLOS (@1%u%u)\n", i, j);
        iprintf (dm, "TRIG SGL\n");
        iscanf  (dm, "%lf", &result);
        iscanf  (dm, "%t", cr);

        iprintf (id, "OPEN (@1%u%u)\n", i, j);
        iprintf (dm, "TRIG SGL\n");
        iscanf  (dm, "%lf", &result2);
        iscanf  (dm, "%t", cr);
        printf ("\nchannel %u%u closed resistance = %.4e Ohms", i, j, result);
        printf ("\n             open   resistance = %.4e Ohms", result2);

        if (result < 3.5) printf ("\n*** Resistance for Channel %u%u is < 3.5 Ohms ***", i,j);

      }

    printf ("\n\nMeasurements complete for High lines.");
    printf ("\nPress ENTER for Low measurements");
    getchar ();

    /*.....................Low Lines.....................*/

    printf ("\n\nLow to Common Measurements");
    printf ("\n\n 1. Connect DMM Input HI lead to Low lines");
    printf ("\n 2. Connect DMM Input LO lead to Common lines");
    printf ("\n 3. Press ENTER when connections are complete");
    getchar ();

    for (i = 0;i <= 7; i++)
      for (j = 0;j <= 7; j++)
      {
        iprintf (id, "CLOS (@1%u%u)\n", i, j);
        iprintf (dm, "TRIG SGL\n");
        iscanf  (dm, "%lf", &result);
        iscanf  (dm, "%t", cr);

        iprintf (id, "OPEN (@1%u%u)\n", i, j);
        iprintf (dm, "TRIG SGL\n");
        iscanf  (dm, "%lf", &result2);
        iscanf  (dm, "%t", cr);
        printf ("\nchannel %u%u closed resistance = %.4e Ohms", i, j, result);
        printf ("\n             open   resistance = %.4e Ohms", result2);

        if (result < 3.5) printf ("\n*** Resistance for Channel %u%u is < 3.5 Ohms ***", i,j);

      }

    printf ("\n\nMeasurements complete for Low lines.");

    iprintf (id, "*RST\n");
    iclose (id);iclose (dm);                          /* Close instrument session */
}
```

Test 2-2: Testing Control Relays

This program performs the control relays test found in *Chapter 2 - Verification Tests*. See Chapter 2 for a detailed description of this test and equipment connections.

```
/*  Closed-channel Resistance Test            E1460A
    This program performs the Control Relay Test found
    in the E1460A Service Manual
    Program Rev. A.01.00  7/1/96  */

#include <stdio.h>
#include <sicl.h>

#define ADDR "hpib7,9,14"                       /* Address of device */
#define DMM "hpib7,22"

void main (void)
{
    INST id, dm;                                /* Define id and dm as an instrument */
    int channel,i;
    double result[13];
    char cr[256];
    char *data[13][3] = {"NC","1W HI","BANK 0 COM HI","NO","1W HI","BANK 0 COM LO",
         "NC","1W LO","CABLE T","NO","1W LO","1W LO REF",
         "HI","AB H1","1W HI","LO","AB L1","1W LO",
         "HI","AB H2","BANK 6 COM HI","LO","AB L2","BANK 6 COM LO",
         "HI","AB H2","AB H1","LO","AB L2","AB L1",
         "HI","BANK 2 COM HI","BANK 4 COM HI","LO","BANK 2 COM LO","BANK 4 COM LO",
         "","AB GUARD","BANK 6 COM LO"};

    #if defined(__BORLANDC__) && !defined(__WIN32__)
     _InitEasyWin();
    #endif

    ionerror(I_ERROR_EXIT);

    dm = iopen (DMM);                           /* Open instrument session */
    id = iopen(ADDR);

    itimeout (dm, 10000);

    printf ("\n\n\nInstall Component Assembly and Test Fixture");
    printf ("\n\n 1. Turn Mainframe AND hp 3458a DMM power OFF.");
    printf ("\n 2. Connect GPIB Cable between mainframe and DMM.");
    printf ("\n 3. Install Agilent E1460A Component Assembly into Mainframe.");
    printf ("\n 4. Attach Test Fixture to Component Assembly.");
    printf ("\n 5. Turn Mainframe and DMM power ON");
    printf ("\n 6. Press ENTER when ready to begin testing.");
    getchar ();

    /*.........................Begin Testing.............*/

    iprintf (id, "*RST\n");
    iprintf (id, "FUNC 1,WIRE2\n");
    iprintf (dm, "PRESET NORM;TRIG HOLD\n");
    iprintf (dm, "END ALWAYS\n");
    iprintf (dm, "FUNC OHMF\n");

    /*.....................Channels 990 and 991.....*/

    i = 0;

    for (channel = 990;channel <= 991; channel++)
    {
```

```
        printf ("\n\nTesting Channel %u %s", channel, data[i][0]);
        printf ("\n Connect DVM HI to %s", data[i][1]);
        printf ("\n Connect DVM LO to %s", data[i][2]);
        printf ("\n Press ENTER when ready");
        getchar ();

        iprintf (id, "OPEN (@10%u)\n", channel);
        iprintf (dm, "TRIG SGL\n");
        iscanf (dm, "%lf", &result[i]);
        iscanf (dm, "%t", cr);
        iprintf (id, "CLOS (@10%u)\n", channel);
        printf ("\nChannel %u %s measures %.4e Ohms", channel, data[i][0], result[i]);

        i++;
        printf ("\n\nTesting Channel %u %s", channel, data[i][0]);
        printf ("\n Connect DVM HI to %s", data[i][1]);
        printf ("\n Connect DVM LO to %s", data[i][2]);
        printf ("\n Press ENTER when ready");
        getchar ();

        iprintf (id, "CLOS (@10%u)\n", channel);
        iprintf (dm, "TRIG SGL\n");
        iscanf (dm, "%lf", &result[i]);
        iscanf (dm, "%t", cr);
        iprintf (id, "OPEN (@10%u)\n", channel);
        printf ("\nChannel %u %s measures %.4e Ohms", channel, data[i][0], result[i]);
        i++;
    }

    for (channel = 992;channel <= 995; channel++)
    {
        printf ("\n\nTesting Channel %u %s", channel, data[i][0]);
        printf ("\n Connect DVM HI to %s", data[i][1]);
        printf ("\n Connect DVM LO to %s", data[i][2]);
        printf ("\n Press ENTER when ready");
        getchar ();

        iprintf (id, "CLOS (@10%u)\n", channel);
        iprintf (dm, "TRIG SGL\n");
        iscanf (dm, "%lf", &result[i]);
        iscanf (dm, "%t", cr);
        iprintf (id, "OPEN (@10%u)\n", channel);
        printf ("\nChannel %u %s measures %.4e Ohms", channel, data[i][0], result[i]);
        i++;

        printf ("\n\nTesting Channel %u %s", channel, data[i][0]);
        printf ("\n Connect DVM HI to %s", data[i][1]);
        printf ("\n Connect DVM LO to %s", data[i][2]);
        printf ("\n Press ENTER when ready");
        getchar ();

        iprintf (id, "CLOS (@10%u)\n", channel);
        iprintf (dm, "TRIG SGL\n");
        iscanf (dm, "%lf", &result[i]);
        iscanf (dm, "%t", cr);
        iprintf (id, "OPEN (@10%u)\n", channel);
        printf ("\nChannel %u %s measures %.4e Ohms", channel, data[i][0], result[i]);
        i++;
    }

    channel = 996;
    printf ("\n\nTesting Channel %u %s", channel, data[i][0]);
    printf ("\n Connect DVM HI to %s", data[i][1]);
    printf ("\n Connect DVM LO to %s", data[i][2]);
```

```
    printf ("\n Press ENTER when ready");
    getchar ();

    iprintf (id, "CLOS (@10%u)\n", channel);
    iprintf (dm, "TRIG SGL\n");
    iscanf (dm, "%lf", &result[i]);
    iscanf (dm, "%t", cr);
    iprintf (id, "OPEN (@10%u)\n", channel);
    printf ("\nChannel %u %s measures %.4e Ohms", channel, data[i][0], result[i]);

    printf ("\n\nMeasurements complete\n");

    channel = 990;
    for (i = 0;i <= 10; i = i + 2)
    {
       printf ("\nChannel: %u %s  = %.4e Ohms", channel, data[i][0], result[i]);
       printf ("\n            %s  = %.4e Ohms", data[i+1][0], result[i+1]);
       channel++;
    }
    printf ("\nChannel: 996 %s  = %.4e Ohms", data[12][0], result[12]);

    iprintf (id, "*RST\n");
    iclose (id);iclose (dm);                        /* Close instrument session */
}
```

Test 2-3: DC Isolation

This test verifies that sufficient DC isolation exists between various points on the multiplexer. See Chapter 2 for hardware connections and equipment setup.

```
/*  DC Isolation Test           E1460A
    This program performs the DC Isolation Test found
    in the E1460A Service Manual
    Program Rev. A.01.00  7/1/96  */

#include <stdio.h>
#include <sicl.h>

#define ADDR "hpib7,9,14"                       /* Address of device */
#define DMM "hpib7,22"

void main (void)
{
    INST id, dm;                                /* Define id and dm as an instrument */
    char reading[256] = {0};                    /* Result variable */
    int channel, i;

    #if defined(__BORLANDC__) && !defined(__WIN32__)
      _InitEasyWin();
    #endif

    ionerror(I_ERROR_EXIT);

    id = iopen (ADDR);                          /* Open instrument session */
    dm = iopen (DMM);

    iprintf (dm, "PRESET NORM;TRIG HOLD\n");
    iprintf (dm, "FUNC OHM;RANGE 1E9\n");
    iprintf (id, "*RST\n");
```

```
    printf ("\n\nConnect DMM HI and LO to E1460A High and Low lines");
    getchar ();

    ipromptf (dm, "TRIG SGL\n", "%t", reading);
    printf ("\nDC Isolation -- High to Low");
    printf ("\n  R = %s Ohms", reading);

    printf ("\n\nConnect DMM HI to E1460A High and Low lines");
    printf ("\nConnect DMM LO to Chassis");
    iprintf (id, "CLOS (@0100:0177)\n");
    getchar ();

    ipromptf (dm, "TRIG SGL\n", "%t", reading);
    printf ("\nDC Isolation -- High and Low Lines to Chassis");
    printf ("\n  R = %s Ohms", reading);

    iprintf (id, "*RST\n");
    iclose (id);                                    /* Close instrument session */
    iclose (dm);
}
```