

Agilent Technologies 87050A Option K12

User's and Service Guide

Use this manual with the following documents:

Agilent 8720D User's Guide
Part Number 08720-90288
and
Agilent 8720D Service Guide
Part Number 08720-90292



Agilent Technologies

Manufacturing Part Number: 87050-90102

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- *Specifications* describe the performance of parameters covered by the product warranty (temperature - 0 to 55 °C, unless otherwise noted.)
- *Typical* describes additional product performance information that is not covered by the product warranty. It is performance beyond specification that 80% of the units exhibit with a 95% confidence level over the temperature range 20 to 30 °C. Typical performance does not include measurement uncertainty.
- *Nominal* values indicate expected performance, or describe product performance that is useful in the application of the product, but is not covered by the product warranty.

Safety Notes

The following safety notes are used throughout this manual. Familiarize yourself with each of the notes and its meaning before operating this instrument. All pertinent safety notes for using this product are located in [Chapter 5, “Safety and Regulatory Information,”](#) on page 66.

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

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1 **General Information**

Description

The Agilent Technologies 87050A Option K12 multiport test set is designed for use with Agilent Technologies 50Ω network analyzers such as the 8720D.

The multiport test set provides the ability to make single connection, multiple measurements of multiport devices such as distribution amplifiers, taps, switches, and couplers. These devices may have up to 12 ports. Throughput is increased by reducing the number of device reconnects the operator must perform. Switching is performed with mechanical switches.

The test set can be controlled by using an external GPIB controller, or parallel control.

NOTE The *87050A Option K12 User's and Service Guide* documents the use of the test set with an 8720D network analyzer only.

Verify the Shipment

After the test set has been unpacked, keep the original packaging materials so they can be used if you need to transport the instrument.

Verify that you have received the items listed below in [Table 1-1](#).

Inspect the test set and all accessories for any signs of damage that may have occurred during shipment. If your test set or any accessories appear to be damaged or missing, refer to [“Contacting Agilent” on page 70](#).

Table 1-1 **87050A Option K12 Accessories Supplied**

| Description | Part Number | Quantity |
|-----------------------------|---|----------|
| Power Cord | See Figure 3-3 on page 37 | 1 |
| Front Handle Kit | 5063-9228 | 1 |
| Rack Mount Kit | 5063-9235 | 1 |
| Parallel Cable | 8120-6818 | 1 |
| RF Cable SMA (f) to SMA (m) | 87050-20345 | 2 |
| RF Cable N (m) to SMA (m) | 87050-20346 | 2 |
| User’s and Service Guide | 87050-90102 | 1 |

Performance Specifications and Characteristics

Table 1-2 Option K12 Performance Specifications and Characteristics

| Parameter | Specification |
|---------------------------------|---|
| Frequency Range | 50 MHz to 20 GHz |
| Isolation^a | |
| 500 MHz to 20.0 GHz | ≥100 dB |
| Return Loss (Switch Path On) | |
| 50.0 MHz to 3.0 GHz | ≥18 dB |
| 3.0 GHz to 12.4 GHz | ≥12 dB |
| 12.4 GHz to 20 GHz | ≥10 dB |
| Return Loss (Switch Path OFF) | |
| 50.0 MHz to 3.0 GHz | ≥22 dB (Typical) |
| 3.0 GHz to 12.4 GHz | ≥14 dB (Typical) |
| 12.4 GHz to 20 GHz | ≥12 dB (Typical) |
| Insertion Loss: | |
| 50 MHz to 3.0 GHz | ≤2.0 dB |
| 3.0 GHz to 6.0 GHz | ≤3.0 dB |
| 6.0 GHz to 12.4 GHz | ≤4.0 dB |
| 12.4 GHz to 20 GHz | ≤5.0 dB |
| Phase Deviation: | |
| Reflection Port to Ports 1–12 | ±15 ° @6 GHz (Typical) ±40 ° @20 GHz (Typical) |
| Transmission Port to Ports 1–12 | ±15 ° @6 GHz (Typical) ±40 ° @20 GHz (Typical) |
| Input Power Damage Level | >1 watt (RF + dc) |

a. From Port-to-Port (1 through 12). Due to the limitations of the 8720D network analyzer, isolation is measured from 500 MHz to 20 GHz.

Requirements

Electrical

The line power module on your test set is an autoranging input. It is designed to be used with an ac power source with a nominal voltage of either 115 V or 230 V.

The alternating-current (ac) power that is supplied to the test set must meet the following requirements:

Voltage: 90 to 250 Vac

Frequency: 48 to 66 Hz

Available power: 40 watts minimum

If the available AC line voltage is outside the 90 to 250 Vac range, an autotransformer that provides third wire continuity to earth ground may be used.

Environmental

Operating Environment

Indoor use only

Operating temperature: 0 to 55 °C

Maximum relative humidity: 80 percent for temperatures up to 31 °C decreasing linearly to 50 percent relative humidity at 40 °C

Altitude: up to 15,000 feet (4,572 meters)

Enclosure protection: IP 20, according to IEC 529

CAUTION This product is designed for use in INSTALLATION CATEGORY II, and POLLUTION DEGREE 2, per IEC 101 and 664 respectively.

Non-Operating Storage Conditions

Temperature: -40 °C to +70 °C

Humidity: 0 to 90 percent relative at +65 °C (non-condensing)

Altitude: 0 to 15,240 meters (50,000 feet)

Weight

Net: Approximately 9 kg

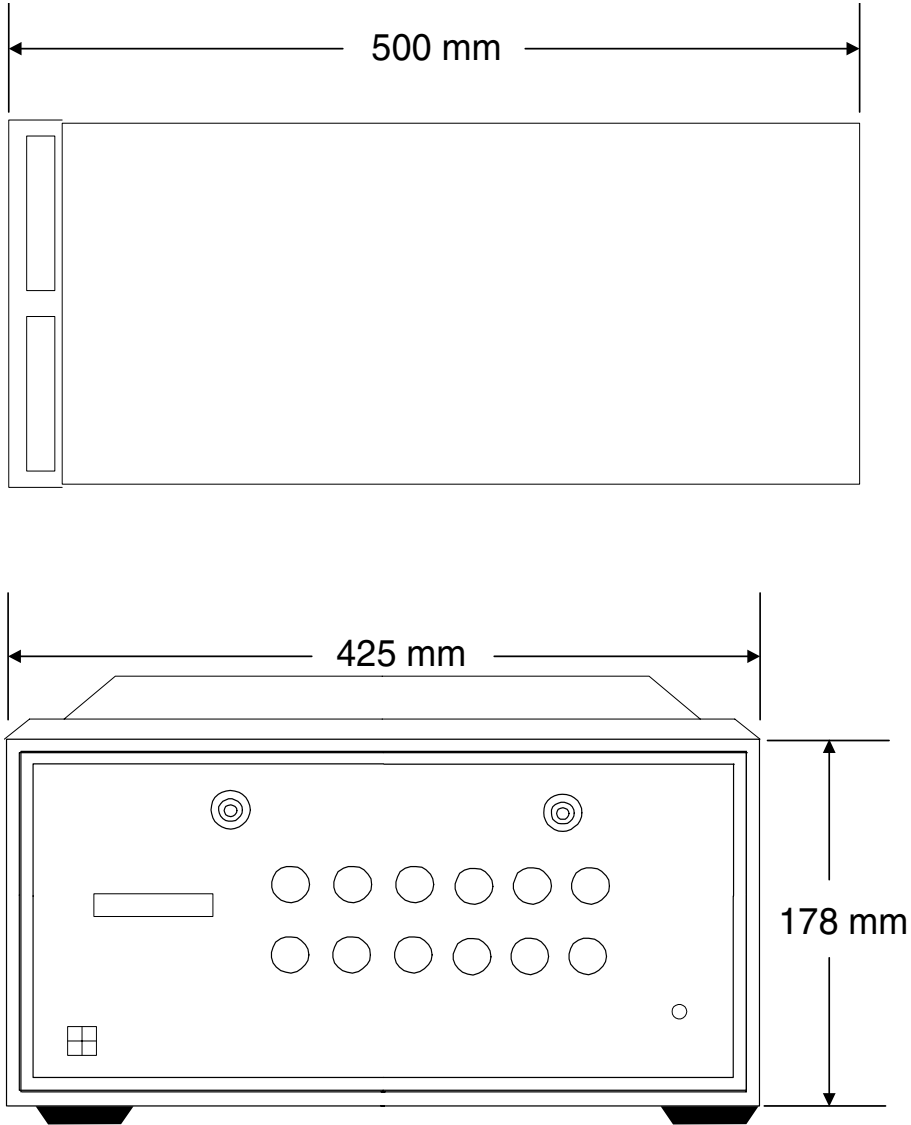
Shipping: Approximately 20 kg

Cabinet Dimensions

These dimensions exclude front and rear panel protrusions.

178 mm Height by 425.0mm Wide by 500 mm Length
(7.01 in by 16.73 in by 19.69 in)

Figure 1-1 Physical Dimensions



Preparations

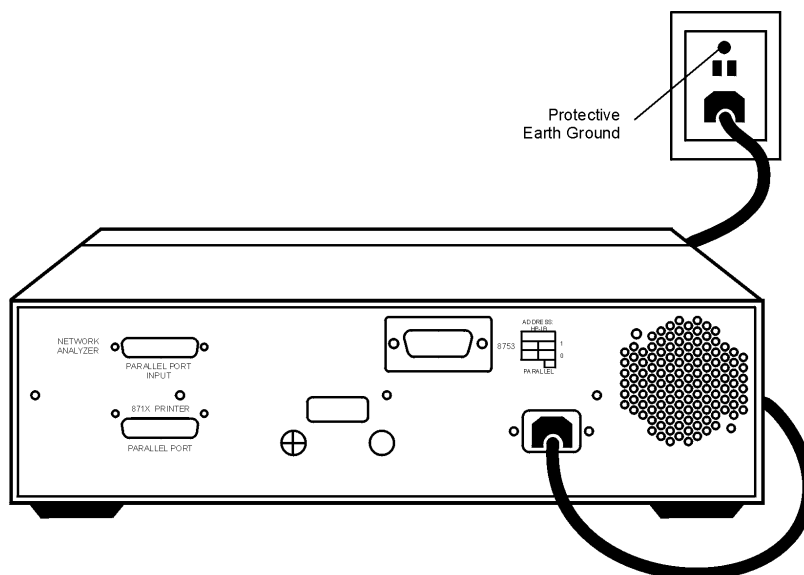
Electrical

1. Ensure that the [“Requirements” on page 11](#) are met.
2. Verify that the power cable is not damaged and that the power source outlet provides a protective earth ground contact.

NOTE Note that [Figure 1-2](#) depicts only one type of power source outlet. Refer to [Figure 3-3 on page 37](#) to see the different types of power cord plugs that can be used with your test set. Cables are available in different lengths. For descriptions and part numbers of cables other than those described in [Figure 3-3](#), Refer to [“Contacting Agilent” on page 70](#).

3. If this product is to be powered by autotransformer, make sure the common terminal is connected to the neutral (grounded) side of the ac power supply.

Figure 1-2 Protective Earth Ground

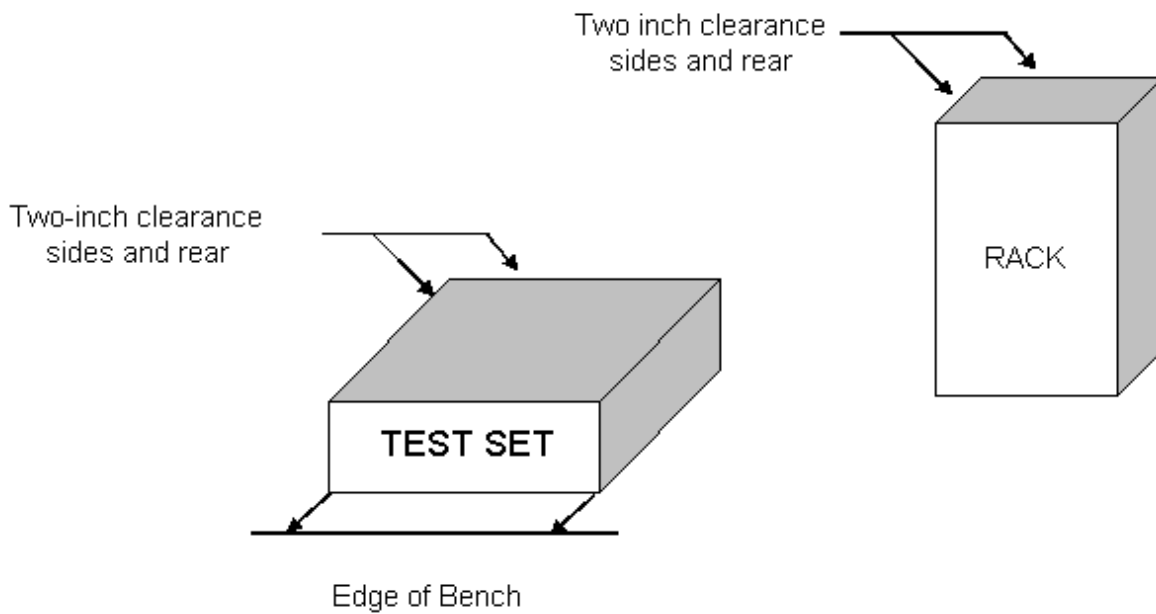


WARNING This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted into a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption of the protective conductor is prohibited.

Environmental

1. Ensure that the “Requirements” on page 11 are met.
2. If you are installing the test set into a cabinet, ensure there are at least two inches of clearance around the sides and back of the test set and the system cabinet. See Figure 1-3. The convection into and out of the test set must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the test set by $4 \times ^\circ\text{C}$ for every 100 watts dissipated in the cabinet.

Figure 1-3 Ventilation Clearance Requirements



CAUTION

If the total power dissipated in the cabinet is greater than 800 watts, forced convection must be used.

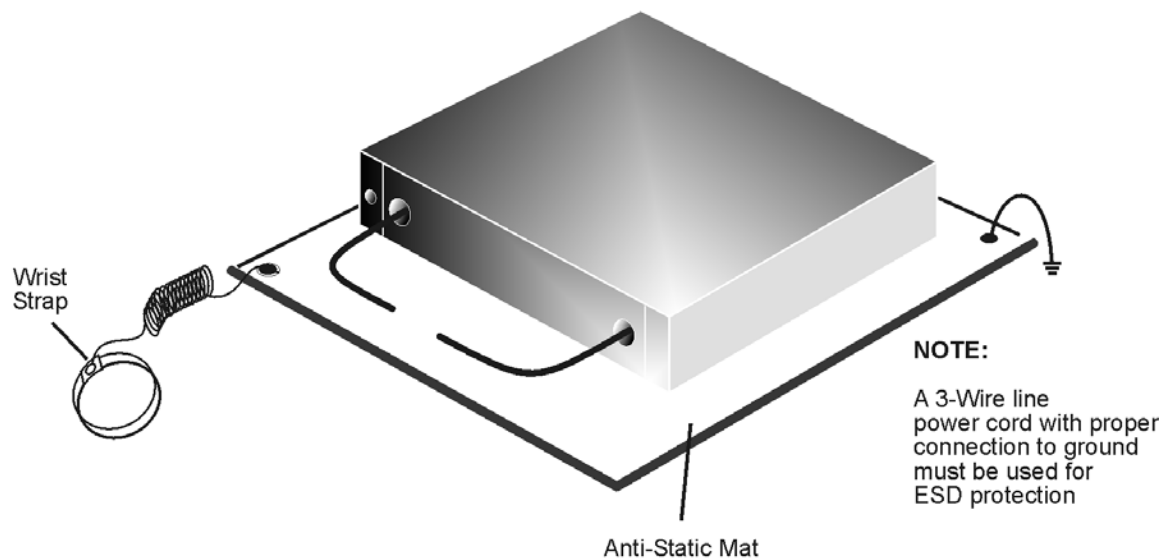
Electrostatic Discharge Protection

Protection against electrostatic discharge (ESD) is essential while removing assemblies from or connecting cables to the network analyzer. Static electricity can build up on your body and can easily damage sensitive internal circuit elements when discharged. Static discharges too small to be felt can cause permanent damage. To prevent damage to the instrument:

- *always* wear a grounded wrist strap having a 1 M Ω resistor in series with it when handling components and assemblies.
- *always* use a grounded, conductive table mat while working on the instrument.
- *always* wear a heel strap when working in an area with a conductive floor. If you are uncertain about the conductivity of your floor, wear a heel strap.
- *always* ground yourself before you clean, inspect, or make a connection to a static-sensitive device or test port. You can, for example, grasp the grounded outer shell of the test port or cable connector briefly.
- *always* ground the center conductor of a test cable before making a connection to the analyzer test port or other static-sensitive device. This can be done as follows:
 1. Connect a short (from your calibration kit) to one end of the cable to short the center conductor to the outer conductor.
 2. While wearing a grounded wrist strap, grasp the outer shell of the cable connector.
 3. Connect the other end of the cable to the test port and remove the short from the cable.

Figure 1-4 shows a typical ESD protection setup using a grounded mat and wrist strap.

Figure 1-4 ESD Protection Setup

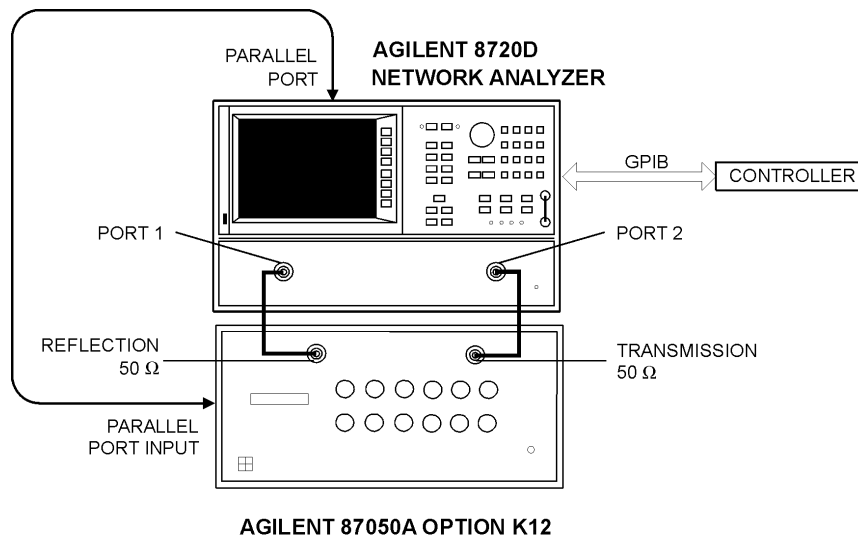


Getting Started

Connecting and Turning On the Test Set

The 87050A Option K12 test set is designed to be placed underneath the network analyzer, in a rack system or on a bench top, and connected as shown in [Figure 1-5](#). Use the two APC 3.5 mm 50 Ω jumper cables (5062-6682) that were shipped with the test set. See [Table 1-1 on page 9](#) for a list of accessories supplied.

Figure 1-5 Connecting the Test Set to the Network Analyzer



Install the parallel cable (8120-6818) from the rear panel PARALLEL connector of the network analyzer to the rear panel PARALLEL INPUT connector of the test set.

Depending on how you will communicate with the test set (see [Chapter 2, “Controlling the Test Set and Making Measurements.”](#)) connecting an GPIB cable from the controller to the rear panel of the network analyzer may also be necessary.

After the proper front and rear panel connections have been made, turn On the test set using the front panel line switch. The front panel line switch disconnects the mains circuits from the mains supply after the EMI filters and before other parts of the instrument.

After the proper front and rear panel connections have been made, turn On the test set using the front panel line switch. The front panel line switch disconnects the mains circuits from the mains supply after the EMI filters and before other parts of the instrument.

CAUTION

For accurate, repeatable measurements, be sure to let the test set warm up for at least two hours. It is recommended that the test set not be turned Off on a regular basis. For the most stable and accurate measurements, leave the test set turned On at all times.

Setting the Test Set Address Switch

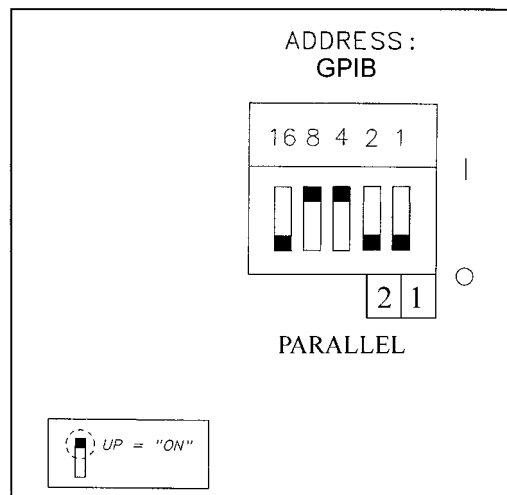
The test set is shipped with the GPIB address set to 12, which sets the parallel address to 0 as in [Figure 1-6](#). Refer to [Chapter 2, “Controlling the Test Set and Making Measurements,”](#) on page 19 for the definition of the parallel address.

To set the GPIB address, set all five switches so that the sum of the switches in the On (or 1) position equal the desired address. In the example below, the two switches in the On position are 8 and 4, thus the GPIB address of 12.

To set the parallel address, use only the number 1 switch. Therefore, the possibilities for parallel port addressing are 0 or 1.

NOTE When GPIB is used, the parallel address is ignored.

Figure 1-6 The Test Set Address Switch



CAUTION Make sure the test set is turned Off before you change the position of any address switch.

Performing the Operator's Check

For information on controlling the test set, refer to [Chapter 2, “Controlling the Test Set and Making Measurements,”](#) on page 19.

Description

The following operator's check is designed to provide you with a high degree of confidence that your test set is working properly. It is not designed to verify specifications. To verify specifications, refer to [Chapter 4 , “Service.”](#)

Procedure

This procedure is for performing a simple operator's check using a network analyzer of the proper frequency range and impedance.

Equipment Required

- Network Analyzer, 50 Ω impedance (8720D)
- Cable, 50 Ω , 3.5 mm (8120-4921 or equivalent), quantity 2
- Calibration Kit, 50 Ω , 3.5 mm (85052B)

Process

1. Connect the 50 Ω cable to PORT 1 of the analyzer.
2. Perform a one-port reflection calibration at the end of the 50 Ω cable over the frequency range of 50 MHz to 20 GHz on the analyzer. Verify that the calibration is active and that a cable terminated with a short displays a return loss of 0 (± 0.2 dB).
3. Connect the cable (already connected to PORT 1 of the analyzer) to the REFLECTION port on the 87050A Option K12 test set.
4. Measure the return loss of each path of the test set by selecting PORT 1 through PORT 12, one at a time, using the network analyzer. Terminate each port being tested with a 50 Ω load (≥ -30 dB). The resulting return loss should be ≥ -12 dB (the absolute value should be greater than 12).
5. Connect the cable (already connected to the REFLECTION port) to the TRANSMISSION port on the test set.
6. Measure the return loss of each path of the test set by selecting PORT 1 through PORT 12, one at a time, using the network analyzer. Terminate each port being tested with a 50 Ω load (≥ -30 dB). The resulting return loss should be greater than -12 dB (the absolute value should be greater than 12).

NOTE This is an 80% confidence test only. A test set could pass this simple test and yet still not function properly. For more complete testing, see [“Performance Tests”](#) on page 41.

Introduction

The 87050A Option K12 is a "slave" instrument: a controller must be used to control the test set. There are three ways in which the test set can be controlled:

- The controller can talk to the network analyzer using GPIB, which then controls the test set via the parallel connection.
- The controller can directly control the test set, using GPIB commands via the GPIB connector.
- A network analyzer equipped with a parallel connection can control the test set directly, or manually.

The next three sections discuss the three methods of control.

Commands

As previously mentioned, there are three ways to control the test set. The first two involve the use of a separate computer. The third way uses the network analyzer manually. These methods of control are detailed in the following sections.

Computer Control via Network Analyzer

One way to control the test set is to write GPIB commands to the 8720D network analyzer which then writes to the test set by way of the parallel port. See [Figure 2-1 on page 22](#) for a diagram of connections for this type of control. The following examples use the variable [D] which is defined in [Table 2-1 on page 23](#).

To use a parallel port connection with the 8720D analyzer, use a GPIB command to write bits on the parallel port. The following example assumes that the address of the network analyzer is 16.

OUTPUT 716;"PARALGPIO;" *Sets the parallel port for
GPIO function*

OUTPUT 716;"PARAOUT[D];" *Programs all GPIO output
bits (0 to 256) at once*

NOTE Be sure to use the ending semi-colon.

Direct Computer Control

The second way to control the test set is to address the 87050A Option K12 test set directly over GPIB, using a controller to write directly to the test set's GPIB port. The following example assumes that the address of the test set is 12.

OUTPUT 712;"command\$"

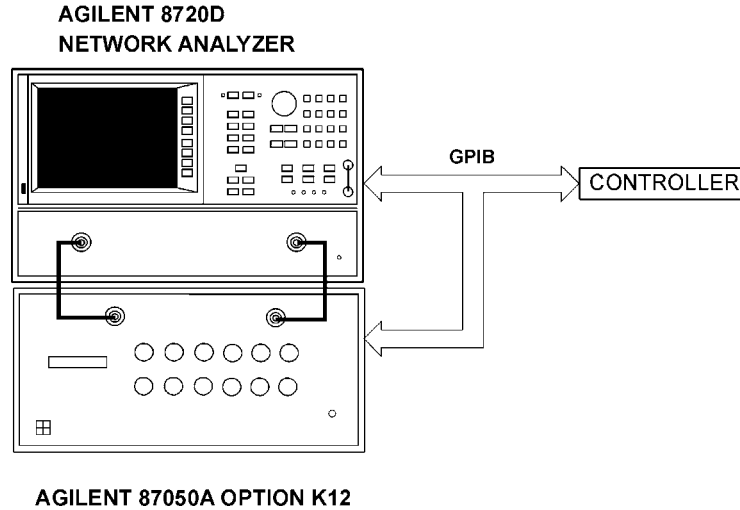
If using Quick Basic or Visual Basic, be sure to disable EOI and EOL before sending commands to the test set. Including the semicolon will not insure that these commands are disabled as would be the case in Basic/RMB. Using the Agilent 82335 GPIB Interface and Visual Basic, the following commands will disable the EOI and EOL, send the necessary data to the test set, and re-enable EOI and EOL. Be sure to re-enable the EOI and EOL before sending data to another instrument.

```
HpibEoi(hHpib;7,0) 'disable EOI
HpibEol(hHpib;7,"",0) 'disable EOL
HpibOutput(hHpib;712,chr$([D])) 'send command to test set
HpibEol(hHpib;7,chr$(13)+chr$(10),2) 're-enable EOL and set
to'chr$(13)+chr$(10)
HpibEoi(hHpib;7,1,) 're-enable EOI
```

where Hpib specifies the handle returned by HpibOpen.

For more information on the EOI and EOL commands, refer to the programming library manual supplied with the Agilent 82335 interface.

Figure 2-1 Controlling the Test Set Over GPIB



NOTE Connection to the network analyzer is not required when controlling the test set over GPIB.

Manual Control via Network Analyzer

The third method of sending commands uses the network analyzer to control the test set directly. This method is performed with the standard setup of the network analyzer working with the test set. A parallel cable is connected from the network analyzer output to the test set input on both rear panels.

The following example for manual control, using the network analyzer, uses normal text in brackets to indicate hard keys and italicized text in brackets to indicated soft keys.

Press:

[Seq]

[TTL I/O] [PARALLEL OUT ALL]

Use the arrow keys (\uparrow or \downarrow) to scroll to the desired test port address, or input the number directly using the hard keys [D] [x1], where D represents the decimal value of the test port address (see [Table 2-1 on page 23](#)).

Table 2-1 Test Port Addresses

| Connection Path | Decimal [D] | Binary Equivalent | GPIB Command |
|-------------------------|--------------------|--------------------------|----------------------|
| Reflection to Port 1 | 0 | 00000000 | refl_01 |
| Reflection to Port 2 | 1 | 00000001 | refl_02 |
| Reflection to Port 3 | 2 | 00000010 | refl_03 |
| Reflection to Port 4 | 3 | 00000011 | refl_04 |
| Reflection to Port 5 | 4 | 00000100 | refl_05 |
| Reflection to Port 6 | 5 | 00000101 | refl_06 |
| Reflection to Port 7 | 6 | 00000110 | refl_07 |
| Reflection to Port 8 | 7 | 00000111 | refl_08 |
| Reflection to Port 9 | 8 | 00001000 | refl_09 |
| Reflection to Port 10 | 9 | 00001001 | refl_10 |
| Reflection to Port 11 | 10 | 00001010 | refl_11 |
| Reflection to Port 12 | 11 | 00001011 | refl_12 |
| Reflection Terminated | 25 | 00011001 | *r_term |
| Transmission to Port 1 | 26 | 00011010 | tran_01 |
| Transmission to Port 2 | 27 | 00011011 | tran_02 |
| Transmission to Port 3 | 28 | 00011100 | tran_03 |
| Transmission to Port 4 | 29 | 00011101 | tran_04 |
| Transmission to Port 5 | 30 | 00011110 | tran_05 |
| Transmission to Port 6 | 31 | 00011111 | tran_06 |
| Transmission to Port 7 | 32 | 00100000 | tran_07 |
| Transmission to Port 8 | 33 | 00100001 | tran_08 |
| Transmission to Port 9 | 34 | 00100010 | tran_09 |
| Transmission to Port 10 | 35 | 00100011 | tran_10 |
| Transmission to Port 11 | 36 | 00100100 | tran_11 |
| Transmission to Port 12 | 37 | 00100101 | tran_12 |
| Transmission Terminated | 50 | 00110010 | *t_term |
| All Ports Terminated | 51 | 00110011 | *all_term |
| Reset | 52 | 00110100 | *rst |
| Test Set Identification | | | idn? |
| Test Set Serial Number | | | sn? |

To connect all ports to their internal 50Ω loads, send the following command by way of the parallel port:

```
OUTPUT 716;"PARALGPIO;"  
OUTPUT 716;"PARAOUT 51;"
```

When a test set port is not in use, it is terminated in 50Ω.

If the 87050A Option K12 is being controlled by GPIB, you can identify the test set serial number by sending the following commands:

```
OUTPUT 712;"sn?"  
ENTER 712;Sn$  
DISP Sn$
```

NOTE This command may only be used with GPIB control.

Reset Command

When the Reset command is sent, the test set is set to the default state where the REFLECTION port is directed to reflection PORT 1 and the TRANSMISSION port is directed to transmission PORT 2.

Switch Count Commands

Reference the 87050A Option K12 block diagram, [Figure 4-1 on page 62](#), for the switch paths.

To read the individual switch count, send the following command:

```
Output 712;"sw14?"
```

The above example shows the command for switch 14 only. This command returns a value which indicates the number of times the particular switch has been addressed and switched. To enter additional commands use [Table 2-2 on page 25](#).

Table 2-2 Switch Count Commands

| Switch Number | GPIB Command |
|----------------------|---------------------|
| SW11 | sw11? |
| SW12 | sw12? |
| SW14 | sw14? |
| SW15 | sw15? |
| SW16 | sw16? |
| SW17 | sw17? |
| SW50 | sw50? |
| SW51 | sw51? |
| SW52 | sw52? |
| SW53 | sw53? |
| SW54 | sw54? |
| SW55 | sw55? |
| SW56 | sw56? |
| SW57 | sw57? |
| SW58 | sw58? |
| SW59 | sw59? |
| SW60 | sw60? |
| SW61 | sw61? |

Calibrating the Test System

After the test set has warmed up for two hours, it should be calibrated before making any measurements. Refer to the network analyzer user's guide to determine the type of calibration for the measurements you will be making.

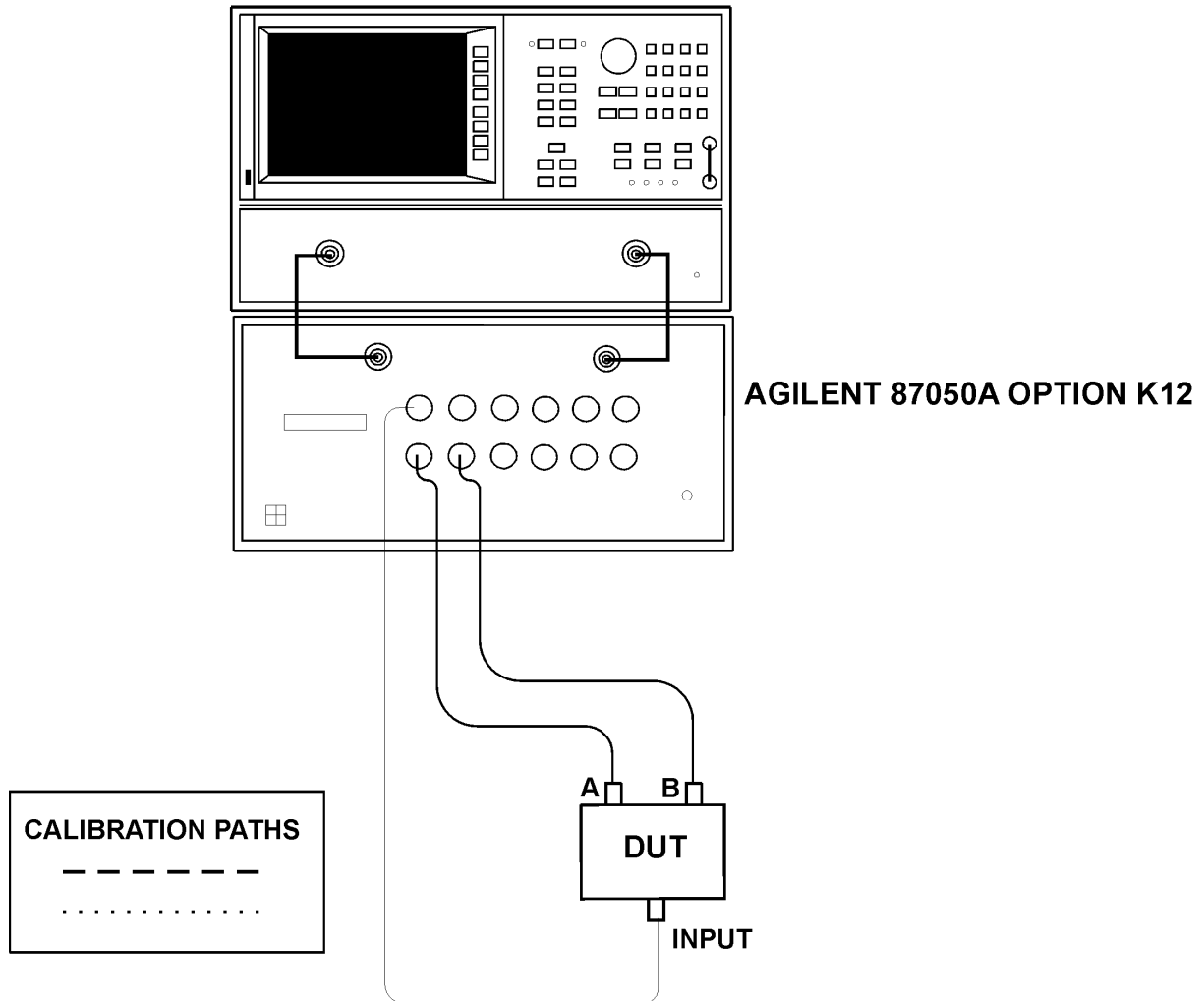
You will need to calibrate each measurement path separately and store the calibration as an instrument state in the network analyzer. Refer to your network analyzer's user's guide for information on how to calibrate and store instrument states. Refer to [Figure 2-2](#) for an example of the setup.

Example Setup

In this setup example, the following tests will be made:

- return loss on the DUT's input and 2 output ports (A and B)
- insertion loss (or gain) between the DUT's input and port A
- insertion loss (or gain) between the DUT's input and port B

Figure 2-2 **Calibrating the Test System**
AGILENT 8720D
NETWORK ANALYZER



For the best accuracy, you should perform a full two-port calibration between the test set PORT 1 and PORT 2, and again between PORT 1 and PORT 4. You need to save the calibrations as instrument states. See your analyzer user's guide for information on calibrations and saving instrument states.

NOTE When performing a full two-port calibration and making subsequent measurements, you must use the transfer switch internal to the network analyzer to change the RF signal path direction. Do not use the test set to change the direction of the RF signal path when you are using a full two-port calibration. Doing so will render the calibration invalid.

Making Measurements

The following examples assume that you are using a parallel port connection with an 8720D, with the test set's parallel address set to 0. See [“Setting the Test Set Address Switch” on page 17](#) for information on setting the test set's address.

Measuring Transmission

Refer to [Figure 2-3](#) for the following discussion. With the 8720D set to measure forward transmission (S_{21}), the analyzer's RF source is being output through the analyzer's PORT 1, and PORT 2 is set to receive the RF signal.

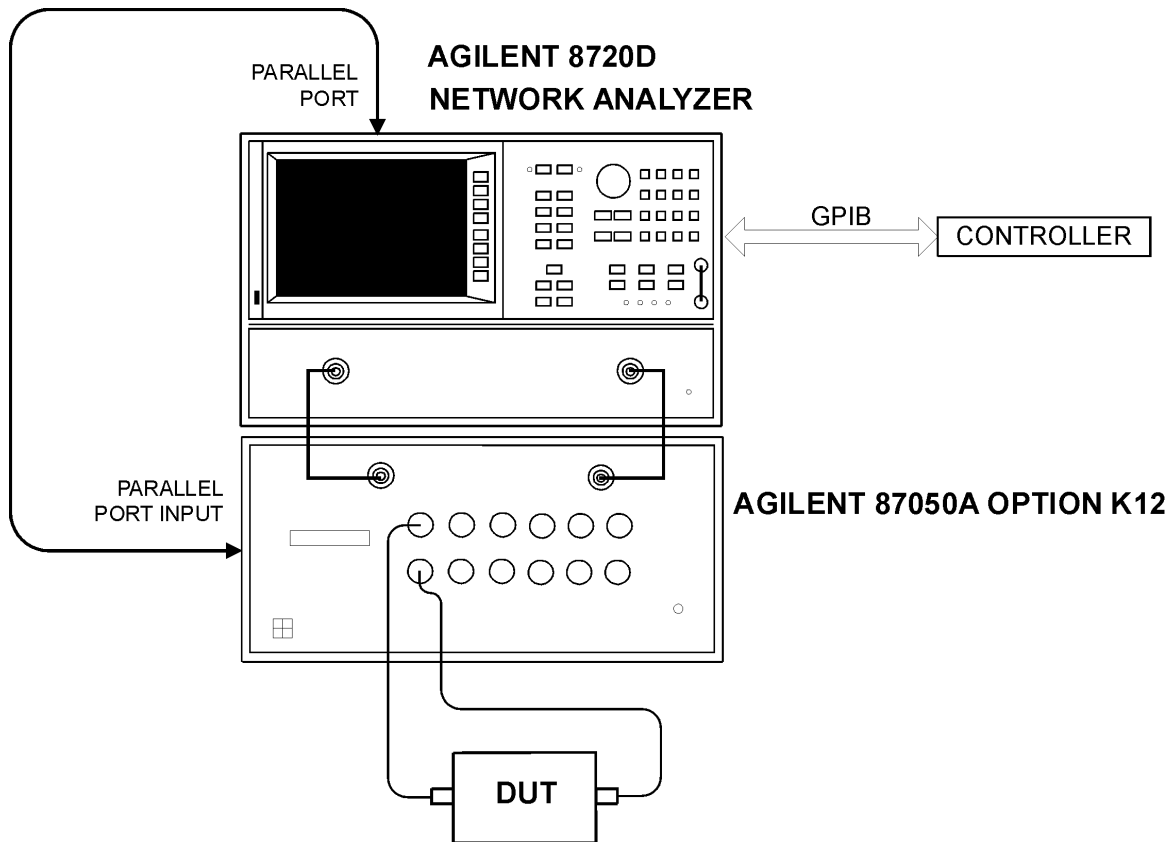
By using the following commands, you will connect PORT 1 of the test set to the REFLECTION port, and you will connect PORT 2 of the test set to the TRANSMISSION port. You will thus be measuring forward transmission through the device under test when measuring S_{21} . This will provide you with gain or insertion loss information.

```
OUTPUT 716;"PARALGPIO;"  
OUTPUT 716;"PARAOUT0;"  
  
OUTPUT 716;"PARALGPIO;"  
OUTPUT 716;"PARAOUT27;"
```

If directly controlling the test set by way of the GPIB interface, use the following GPIB commands:

```
OUTPUT 712;"refl_01"  
OUTPUT 712;"tran_02"
```

Figure 2-3 Controlling the Test Set



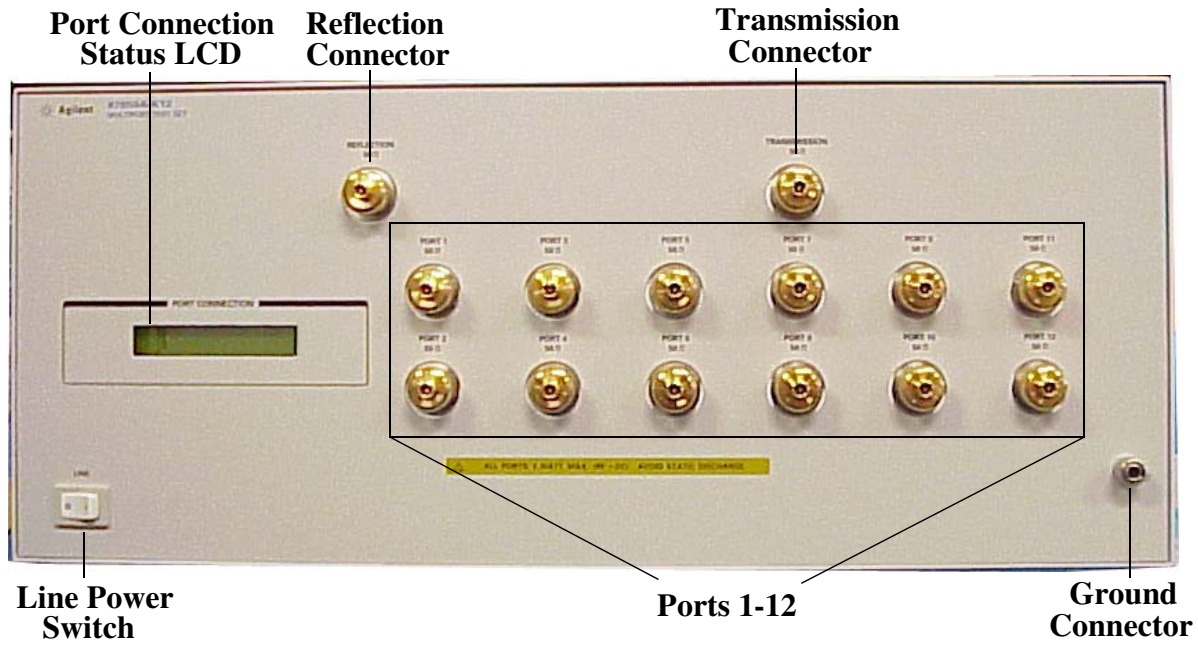
Measuring Reflection

By leaving the DUT connected as in [Figure 2-3](#) and setting the network analyzer to measure S_{11} , you can measure reflection or return loss.

3 **Front/Rear Panel**

Front Panel

Figure 3-1 Front Panel Features



The Port Connection Status LCD

The port connection status LCD provides visual feedback of which port(s) are connected to the REFLECTION and TRANSMISSION ports of the test set. When the LCD displays a path connection, all other corresponding test ports are internally terminated in 50Ω.

The REFLECTION and TRANSMISSION Ports

The REFLECTION and TRANSMISSION ports are 50Ω, 3.5 mm connectors. A 50Ω cable connects directly to the REFLECTION/TRANSMISSION port or PORT 1/PORT 2 of the network analyzer using the cables (5062-6682) that were shipped with your test set.

CAUTION

Check your analyzer's documentation for damage limits to the ports. Make sure that your test setup will not cause those limits to be exceeded.

Line Power Switch

The test set line power switch is located at the bottom left corner of the front panel. See [Figure 3-1](#). The line power switch turns the power to the test set either On (|) or Off (O).

The front panel line switch disconnects the mains circuits from the mains supply after the EMI filters and before others parts of the instrument.

Ports 1—12

PORTS 1 through 12 are 50Ω, 3.5 mm connectors that are used to connect to the device under test.

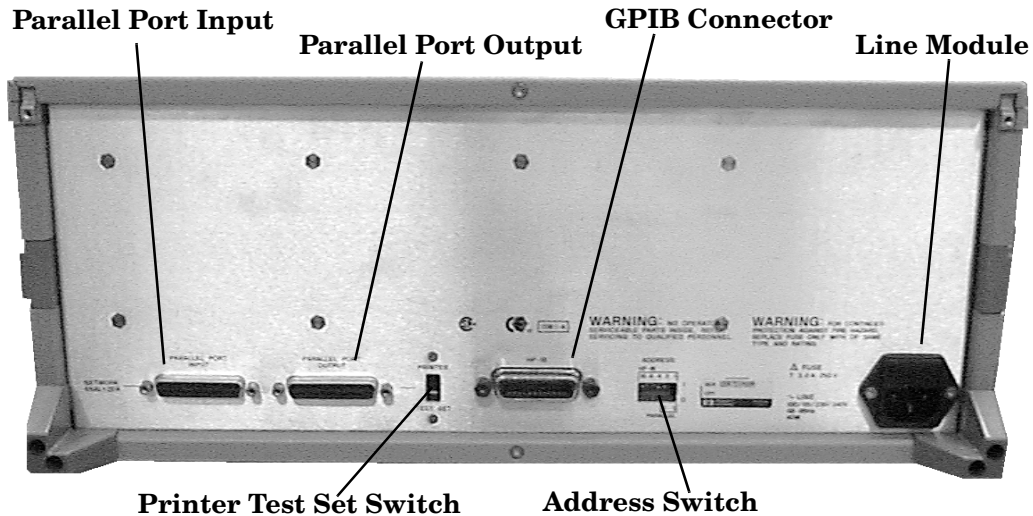
CAUTION Do not input more than 1 watt (RF and dc combined) to these ports, or damage to the internal RF switches or the analyzer may occur.

The GROUND Connector

The GROUND connector provides a convenient front panel ground connection for a standard banana plug.

Rear Panel

Figure 3-2 Rear Panel Features



The Parallel Port Input Connector

This input is connected to the network analyzer. The analyzer provides control signals that drive the switches inside the test set. In pass-through mode, it also accepts signals required to drive a printer.

The Parallel Port Output Connector

The output from this connector is used to either control another test set, or to control a printer, depending upon how the Printer/Test Set switch is set.

The Printer/Test Set Switch

This switch determines the function of the Parallel Port Output connector. When switched to Printer, the Parallel Port Output will pass-through printer driver signals. When switched to Test Set, an additional test set can be controlled from the Parallel Port Output connector.

GPIB Connector

This connector allows the test set to be connected directly to a controller.

Address Switch

The address switch sets the GPIB or parallel address of the test set. For more information refer to, [“Setting the Test Set Address Switch” on page 17.](#)

Line Module

The line module contains the power cable receptacle and the line fuse.

Power Cables

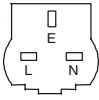

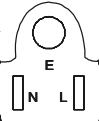
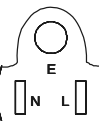
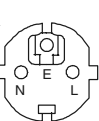
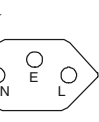

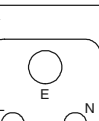

The line power cable is supplied in one of several configurations, depending on the destination of the original shipment.

Each instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument chassis. The type of power cable shipped with each instrument depends on the country of destination. See [Figure 3-3, “Power Cable and Line \(Mains\) Plug Part Numbers” on page 37](#) for the part numbers of the power cables. Cables are available in different lengths. Use [“Contacting Agilent” on page 70](#) for descriptions and part numbers of cables other than those described in [Figure 3-3](#).

CAUTION Always use the three-prong ac power cord supplied with this product. Failure to ensure adequate grounding by not using this cord may cause damage to the product.

WARNING **This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted into a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.**

Figure 3-3 Power Cable and Line (Mains) Plug Part Numbers

| Plug Type ^a | Cable Part Number | Plug ^b Description | Length cm (in.) | Cable Color | For Use in Country |
|---|-------------------|-------------------------------|-----------------|-------------|--|
| 250V  | 8120-8705 | Straight BS 1363A | 229 (90) | Mint Gray | Option 900 United Kingdom, Hong Kong, Cyprus, Nigeria, Singapore, Zimbabwe |
| | 8120-8709 | 90° | 229 (90) | Mint Gray | |
| 250V  | 8120-1369 | Straight AS 3112 | 210 (79) | Gray | Option 901 Argentina, Australia, New Zealand, Mainland China |
| | 8120-0696 | 90° | 200 (78) | Gray | |
| 125V  | 8120-1378 | Straight NEMA 5-15P | 203 (80) | Jade Gray | Option 903 United States, Canada, Brazil, Colombia, Mexico, Philippines, Saudi Arabia, Taiwan |
| | 8120-1521 | 90° | 203 (80) | Jade Gray | |
| 125V  | 8120-4753 | Straight NEMA 5-15P | 229 (90) | Gray | Option 918 Japan |
| | 8120-4754 | 90° | 229 (90) | Gray | |
| 250V  | 8120-1689 | Straight CEE 7/VII | 200 (78) | Mint Gray | Option 902 Continental Europe, Central African Republic, United Arab Republic |
| | 8120-1692 | 90° | 200 (78) | Mint Gray | |
| 230V  | 8120-2104 | Straight SEV Type 12 | 200 (78) | Gray | Option 906 Switzerland |
| | 8120-2296 | 90° | 200 (78) | Gray | |
| 220V  | 8120-2956 | Straight SR 107-2-D | 200 (78) | Gray | Option 912 Denmark |
| | 8120-2957 | 90° | 200 (78) | Gray | |
| 250V  | 8120-4211 | Straight IEC 83-B1 | 200 (78) | Mint Gray | Option 917 South Africa, India |
| | 8120-4600 | 90° | 200 (78) | Mint Gray | |
| 250V  | 8120-5182 | Straight SI 32 | 200 (78) | Jade Gray | Option 919 Israel |
| | 8120-5181 | 90° | 200 (78) | Jade Gray | |

a. E =earth ground, L = line, and N = neutral.
b. Plug identifier numbers describe the plug only. The Agilent Technologies part number is for the complete cable assembly.

The Line Fuse

The line fuse, as well as a spare, reside within the line module. [Figure 3-3](#) illustrates where the fuses are and how to access them.

Available Fuses

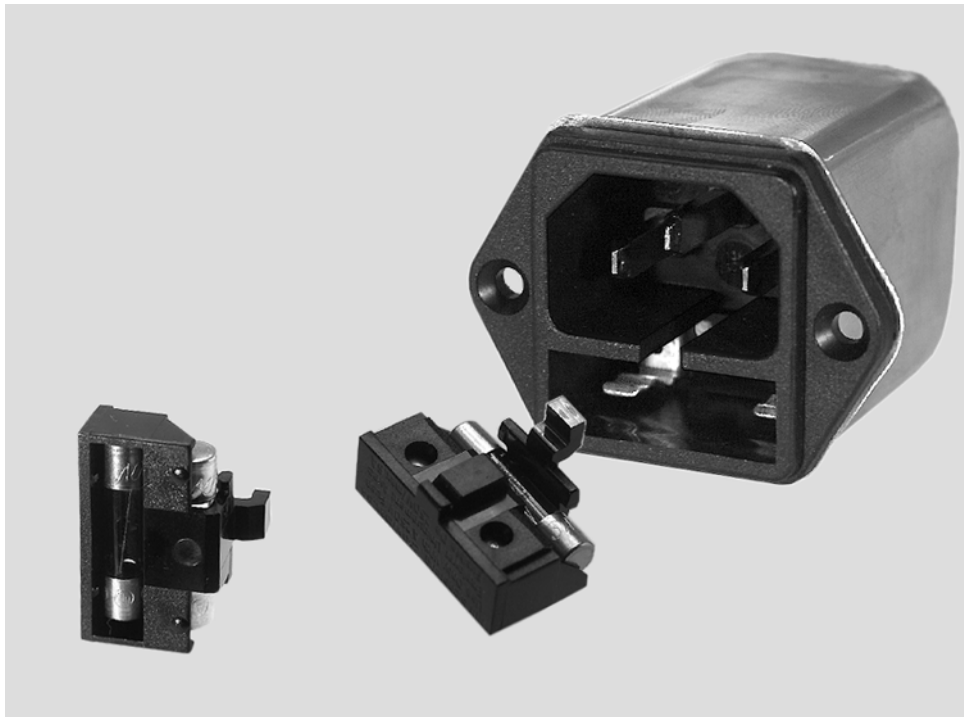
United States (115 V orientation)

Fuse (F 3 A/250 V, 2110-0780) U.L. listed and CSA certified

Europe (230 V orientation)

Fuse (F 3.15 A/250 V, 2110-0655) IEC certified and U.L. recognized

Figure 3-4 **Location of Line Fuses**



4 **Service**

Introduction

This chapter contains information on the theory of operation, how to verify the performance of your test set, how to troubleshoot it if necessary and a block diagram.

NOTE Please read all applicable safety warnings and cautions in [Chapter 5](#) before servicing the test set.

Performance Tests

Performance testing consists of measuring insertion loss, return loss, and isolation between all ports. For the most accurate measurements, the use of an 8720D 50 Ω network analyzer is recommended and its use is assumed in these notes. Familiarity with RF/microwave measurements is also assumed. The use of adapters may be required and their effects should be accounted within the measurements.

Equipment Required

- 8720D Network Analyzer
- Test Port Extension Cables and Adapters
- 85052B Calibration Kit (50 Ω , 3.5 mm)
- 909D or 00909-60006, 50 Ω Load

NOTE Make a photocopy of the performance test record (later in this chapter) to record the results of the performance tests.

There are no adjustments required for the 87050A Option K12 test set.

Set up the network analyzer with the following:

1. Number of points to 401
2. IF Bandwidth to 30 Hz

Perform a full two-port calibration from 50 MHz to 20 GHz at the ends of two cables attached to the two test ports of the 8720D. The cable on PORT 1 of the network analyzer should interface with the TRANSMISSION or REFLECTION ports on the front panel of the test set, and the cable on PORT 2 of the analyzer should interface with the test ports (1 through 12) on the front panel of the test set.

NOTE The isolation calibration routine is done with 16 averages.

NOTE Throughout this manual, the following conventions are observed:

[Hardkeys] are labeled, front panel keys.

Softkeys are display-defined keys (in the menus).

Insertion Loss

1. Connect the cable attached to PORT 1 of the network analyzer to the TRANSMISSION port of the test set.
2. Connect the cable from PORT 2 of the network analyzer to PORT 1 of the test set.
3. Select the `all_term` command using the network analyzer by pressing:
[SEQ] > [TTL I/O] > Parallel All Out > [51] > [X1]
This command will ensure that no conflicts will occur when selecting the test set ports. For complete information on controlling the test set, refer to [Chapter 2, “Controlling the Test Set and Making Measurements,”](#) on page 19.

NOTE Reflection and transmission cannot be directed to the same port. If the test set does not switch to the port you have selected, switch the other port to either 1 or 4.

4. Select Transmission Port 1 by pressing:
[SEQ] > [TTL I/O] > Parallel All Out > [51] > [X1]
Enter the decimal value (D in [Table 2-1, “Test Port Addresses,”](#) on page 23 to select the port, then press:
[x1]
5. Check the status LCD on the test set to verify the port has been selected.
6. On the network analyzer, press:
[MENU] > Trigger Menu > Single
Wait until the analyzer is finished taking a sweep, then press:
[SCALE REF] > Auto Scale > [MARKER]
7. Locate the minimum value of the data trace for the following frequency ranges using the front panel knob:
 - 50.0 MHz to 3.0 GHz
 - 3.0 GHz to 6.0 GHz
 - 6.0 GHz to 12.4 GHz
 - 12.4 GHz to 20.0 GHz
8. Write the minimum value in the Performance Test Record, starting on [page 48](#), for the port being measured.
9. Repeat steps 5 through 8 for the remaining test ports (2 through 12) listed in the Performance Test Record.
10. After all transmission ports have been measured, move the cable attached to the TRANSMISSION port to the REFLECTION port on the test set. Repeat steps 4 through 9, but select the reflection ports instead of the transmission ports.

Return Loss

This test will check the internal termination load of each port, and the through match when the appropriate input port is terminated with a 50Ω load.

1. Connect the cable attached to PORT 1 of the analyzer to PORT 1 of the test set.
2. Connect a 50Ω load to the TRANSMISSION port of the test set.
3. Select the all_term command using the network analyzer by pressing:
[SEQ] > [TTL I/O] > Parallel All Out > [51] > [X1]
 This command will ensure that no conflicts will occur when selecting the test set ports.
4. Select Transmission Port 1 on the network analyzer by pressing:
[SEQ] > [TTL I/O] > Parallel All Out
 This will turn the switching path on.
 Enter the decimal value (D in [Table 2-1, “Test Port Addresses,” on page 23](#)) to select the port, then press:
[x1]
5. Check the status LCD to verify the port has been selected.
6. On the network analyzer press:
[MENU] > Trigger > Single
 Wait until the analyzer is finished taking a sweep, then press:
[SCALE REF] > Auto Scale > [MARKER]
7. Locate the maximum value of the data trace for the following frequency ranges using the front panel knob:
 - 50.0 MHz to 3.0 GHz
 - 3.0 GHz to 12.4 GHz
 - 12.4 GHz to 20.0 GHz
8. Write the value in the Performance Test Record starting on [page 52](#) for the port being measured, under “Switch Path ON.”
9. Repeat the previous two steps (7 and 8) for the remaining ports listed in the Performance Test Record, under “Switch Path ON.”
10. Turnoff the switching path by pressing:
[SEQ] > [TTL I/O] > Parallel Out All > [51] > [X1]
11. Locate the maximum value of the data trace for the following frequency ranges using the front panel knob:
 - 50.0 MHz to 3.0 GHz
 - 3.0 GHz to 12.4 GHz
 - 12.4 GHz to 20.0 GHz
12. Write the value in the Performance Test Record, starting on [page 55](#) for the port being measured, under “Switch Path OFF.”

Service
Performance Tests

13. Repeat the previous two steps (11 and 12) for the remaining ports listed in the Performance Test Record, under “Switch Path OFF.”
14. After all the transmission ports have been measured, move the 50Ω load to the REFLECTION port on the test set. Repeat steps 3 through 13, but select the reflection ports instead of the transmission ports.

Isolation

NOTE Isolation needs to only be measured on adjacent ports. Two 50Ω loads are required for this test.

1. Connect two 50Ω loads to both the TRANSMISSION and REFLECTION ports on the test set.
2. Turn On the averaging by pressing:
[AVG] > Averaging On
3. Connect the two cables (attached to the network analyzer) to PORT 1 and PORT 2 of the test set. The exact order does not matter.
4. Select Reflection Port 1 on the network analyzer by pressing:
[SEQ] > [TTL I/O] > Parallel All Out
Enter the decimal value (D in [Table 2-1, “Test Port Addresses,” on page 23](#)) to select the port, then press:
[x1]
5. Repeat step 4, but select Transmission Port 2 on the network analyzer. Check the status LCD on the test set for the port selected.
6. On the network analyzer, press:
[MENU] > Trigger Menu > Number of Groups > [16] > [X1]
Wait until the analyzer is finished making the measurement, then press:
[SCALE REF] > Auto Scale > [MARKER]
7. Locate the maximum value of the data trace for the 500 MHz to 20.0 GHz frequency range using the front panel knob.
8. Write the maximum value in the Performance Test Record, on [page 57](#), for the ports being measured.
9. Repeat steps 5 through 8 for the next two adjacent ports, 2 and 3. Repeat again for ports 3 and 4, and then for ports 4 and 5, and so on until you have tested ports 11 and 12. This completes the Performance Testing instructions.

Performance Test Record

The following pages (Performance Test Record) are designed to be duplicated and used as a template for either of the Transmission or Reflection Ports during each of the performance tests (Insertion Loss, Return Loss, and Isolation). At the top of each page, circle the appropriate input port, Transmission or Reflection, and write in the test date.

87050A Option K12 Test Record

Test Facility _____

Report Number _____

Date _____

Date of Last System Calibration _____

Tested by _____

Customer _____

Model _____

Serial Number _____

Ambient Temperature _____ °C

Relative Humidity _____ %

Test Equipment Used Model Number

Trace Number

Cal Due Date

Special Notes:

87050A Option K12 Insertion Loss Test Record

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty | |
|---|---------------------|-------------------|------------------|-------------------------|--|
| Insertion Loss 50.0 MHz to 3.0 GHz | Transmission | | | | |
| | Port 1 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 2 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 3 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 4 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 5 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 6 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 7 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 8 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 9 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 10 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 11 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 12 | ≤2.00 dB | _____ | ±0.3 dB | |
| | | Reflection | | | |
| | Port 1 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 2 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 3 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 4 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 5 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 6 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 7 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 8 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 9 | ≤2.00 dB | _____ | ±0.3 dB | |
| | Port 10 | ≤2.00 dB | _____ | ±0.3 dB | |
| Port 11 | ≤2.00 dB | _____ | ±0.3 dB | | |
| Port 12 | ≤2.00 dB | _____ | ±0.3 dB | | |

87050A Option K12 Insertion Loss Test Record

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty |
|--|---------------------|---------------|------------------|-------------------------|
| Insertion Loss 3.0 GHz to 6.0 GHz | Transmission | | | |
| | Port 1 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 2 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 3 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 4 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 5 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 6 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 7 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 8 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 9 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 10 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 11 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 12 | ≤3.00 dB | _____ | ±0.3 dB |
| | Reflection | | | |
| | Port 1 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 2 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 3 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 4 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 5 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 6 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 7 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 8 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 9 | ≤3.00 dB | _____ | ±0.3 dB |
| | Port 10 | ≤3.00 dB | _____ | ±0.3 dB |
| Port 11 | ≤3.00 dB | _____ | ±0.3 dB | |
| Port 12 | ≤3.00 dB | _____ | ±0.3 dB | |

87050A Option K12 Insertion Loss Test Record

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty | |
|---|---------------------|-------------------|------------------|-------------------------|--|
| Insertion Loss 6.0 GHz to 12.4 GHz | Transmission | | | | |
| | Port 1 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 2 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 3 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 4 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 5 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 6 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 7 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 8 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 9 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 10 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 11 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 12 | ≤4.00 dB | _____ | ±0.3 dB | |
| | | Reflection | | | |
| | Port 1 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 2 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 3 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 4 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 5 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 6 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 7 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 8 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 9 | ≤4.00 dB | _____ | ±0.3 dB | |
| | Port 10 | ≤4.00 dB | _____ | ±0.3 dB | |
| Port 11 | ≤4.00 dB | _____ | ±0.3 dB | | |
| Port 12 | ≤4.00 dB | _____ | ±0.3 dB | | |

87050A Option K12 Insertion Loss Test Record

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty |
|--|---------------------|---------------|------------------|-------------------------|
| Insertion Loss 12.4 GHz to 20.0 GHz | Transmission | | | |
| | Port 1 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 2 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 3 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 4 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 5 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 6 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 7 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 8 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 9 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 10 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 11 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 12 | ≤5.00 dB | _____ | ±0.3 dB |
| | Reflection | | | |
| | Port 1 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 2 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 3 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 4 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 5 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 6 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 7 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 8 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 9 | ≤5.00 dB | _____ | ±0.3 dB |
| | Port 10 | ≤5.00 dB | _____ | ±0.3 dB |
| Port 11 | ≤5.00 dB | _____ | ±0.3 dB | |
| Port 12 | ≤5.00 dB | _____ | ±0.3 dB | |

87050A Option K12 Return Loss Test Record (Sw. Path ON)

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty |
|--|---------------------|---------------|------------------|-------------------------|
| <p>Return Loss 50.0 MHz to 3.0 GHz Switch Path ON</p> | Transmission | | | |
| | Port 1 | ≥18 dB | _____ | ±1.5 dB |
| | Port 2 | ≥18 dB | _____ | ±1.5 dB |
| | Port 3 | ≥18 dB | _____ | ±1.5 dB |
| | Port 4 | ≥18 dB | _____ | ±1.5 dB |
| | Port 5 | ≥18 dB | _____ | ±1.5 dB |
| | Port 6 | ≥18 dB | _____ | ±1.5 dB |
| | Port 7 | ≥18 dB | _____ | ±1.5 dB |
| | Port 8 | ≥18 dB | _____ | ±1.5 dB |
| | Port 9 | ≥18 dB | _____ | ±1.5 dB |
| | Port 10 | ≥18 dB | _____ | ±1.5 dB |
| | Port 11 | ≥18 dB | _____ | ±1.5 dB |
| | Port 12 | ≥18 dB | _____ | ±1.5 dB |
| | Reflection | | | |
| | Port 1 | ≥18 dB | _____ | ±1.5 dB |
| | Port 2 | ≥18 dB | _____ | ±1.5 dB |
| | Port 3 | ≥18 dB | _____ | ±1.5 dB |
| | Port 4 | ≥18 dB | _____ | ±1.5 dB |
| | Port 5 | ≥18 dB | _____ | ±1.5 dB |
| | Port 6 | ≥18 dB | _____ | ±1.5 dB |
| | Port 7 | ≥18 dB | _____ | ±1.5 dB |
| | Port 8 | ≥18 dB | _____ | ±1.5 dB |
| | Port 9 | ≥18 dB | _____ | ±1.5 dB |
| | Port 10 | ≥18 dB | _____ | ±1.5 dB |
| Port 11 | ≥18 dB | _____ | ±1.5 dB | |
| Port 12 | ≥18 dB | _____ | ±1.5 dB | |

87050A Option K12 Return Loss Test Record (Sw. Path ON)

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty | |
|--|---------------------|-------------------|------------------|-------------------------|--|
| <p>Return Loss 3.0 GHz to 12.4 GHz Switch Path ON</p> | Transmission | | | | |
| | Port 1 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 11 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 12 | ≥12 dB | _____ | ±0.6 dB | |
| | | Reflection | | | |
| | Port 1 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥12 dB | _____ | ±0.6 dB | |
| Port 11 | ≥12 dB | _____ | ±0.6 dB | | |
| Port 12 | ≥12 dB | _____ | ±0.6 dB | | |

87050A Option K12 Return Loss Test Record (Sw. Path ON)

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty | |
|--|---------------------|-------------------|------------------|-------------------------|--|
| Return Loss 12.4 GHz to 20.0 GHz Switch Path ON | Transmission | | | | |
| | Port 1 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 11 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 12 | ≥10 dB | _____ | ±0.6 dB | |
| | | Reflection | | | |
| | Port 1 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥10 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥10 dB | _____ | ±0.6 dB | |
| Port 11 | ≥10 dB | _____ | ±0.6 dB | | |
| Port 12 | ≥10 dB | _____ | ±0.6 dB | | |

87050A Option K12 Return Loss Test Record (Sw. Path OFF)

| Test Description | Port | Specification (Typical) | Measured Results | Measurement Uncertainty | |
|---|---------------------|----------------------------|---------------------|----------------------------|--|
| <p>Return Loss 50.0 MHz to 3.0 GHz Switch Path OFF</p> | Transmission | | | | |
| | Port 1 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 2 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 3 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 4 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 5 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 6 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 7 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 8 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 9 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 10 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 11 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 12 | ≥22 dB | _____ | ±1.5 dB | |
| | | Reflection | | | |
| | Port 1 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 2 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 3 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 4 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 5 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 6 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 7 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 8 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 9 | ≥22 dB | _____ | ±1.5 dB | |
| | Port 10 | ≥22 dB | _____ | ±1.5 dB | |
| Port 11 | ≥22 dB | _____ | ±1.5 dB | | |
| Port 12 | ≥22 dB | _____ | ±1.5 dB | | |

87050A Option K12 Return Loss Test Record (Sw. Path OFF)

| Test Description | Port | Specification (Typical) | Measured Results | Measurement Uncertainty | |
|--|---------------------|-------------------------|------------------|-------------------------|--|
| Return Loss 3.0 GHz to 12.4 GHz Switch Path OFF | Transmission | | | | |
| | Port 1 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 11 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 12 | ≥14 dB | _____ | ±0.6 dB | |
| | Reflection | | | | |
| | Port 1 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥14 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥14 dB | _____ | ±0.6 dB | |
| Port 11 | ≥14 dB | _____ | ±0.6 dB | | |
| Port 12 | ≥14 dB | _____ | ±0.6 dB | | |

87050A Option K12 Return Loss Test Record (Sw. Path OFF)

| Test Description | Port | Specification (Typical) | Measured Results | Measurement Uncertainty | |
|---|---------------------|-------------------------|------------------|-------------------------|--|
| Return Loss 12.4 GHz to 20.0 GHz Switch Path OFF | Transmission | | | | |
| | Port 1 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 11 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 12 | ≥12 dB | _____ | ±0.6 dB | |
| | Reflection | | | | |
| | Port 1 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 2 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 3 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 4 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 5 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 6 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 7 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 8 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 9 | ≥12 dB | _____ | ±0.6 dB | |
| | Port 10 | ≥12 dB | _____ | ±0.6 dB | |
| Port 11 | ≥12 dB | _____ | ±0.6 dB | | |
| Port 12 | ≥12 dB | _____ | ±0.6 dB | | |

87050A Option K12 Isolation Test Record

| Test Description | Port | Specification | Measured Results | Measurement Uncertainty |
|--|------------|---------------|------------------|-------------------------|
| Isolation 500.0 MHz to 20.0 GHz | Port 1-2 | ≥100 dB | _____ | ±5 dB |
| | Port 2-3 | ≥100 dB | _____ | ±5 dB |
| | Port 3-4 | ≥100 dB | _____ | ±5 dB |
| | Port 4-5 | ≥100 dB | _____ | ±5 dB |
| | Port 5-6 | ≥100 dB | _____ | ±5 dB |
| | Port 6-7 | ≥100 dB | _____ | ±5 dB |
| | Port 7-8 | ≥100 dB | _____ | ±5 dB |
| | Port 8-9 | ≥100 dB | _____ | ±5 dB |
| | Port 9-10 | ≥100 dB | _____ | ±5 dB |
| | Port 10-11 | ≥100 dB | _____ | ±5 dB |
| | Port 11-12 | ≥100 dB | _____ | ±5 dB |

Replaceable Parts

The following table contains the list of replaceable parts for the 87050A Option K12 multiport test set. If any of these parts or assemblies are replaced, you must run all performance tests to verify conformance to specifications.

Table 4-1 Replaceable Parts

| Replacement Part | Part Number | Quantity |
|--------------------------------------|-------------|----------|
| Power Supply, 110W | 0950-2252 | 1 |
| Feet, Spring | 1460-1345 | 2 |
| Fuse, daughter control board | 2110-0518 | 1 |
| Fuse, 3A 250V (f), ac line module | 2110-0780 | 2 |
| Switch Assembly, 33314-024 | 33314-60012 | 12 |
| Cover, top | 5002-1047 | 1 |
| Cover, bottom | 5002-1088 | 1 |
| Cover, side | 5002-3985 | 2 |
| Shield, power supply | 5002-4017 | 1 |
| Frame, rear | 5021-5806 | 1 |
| Strut, side | 5021-5837 | 4 |
| Frame, front | 5022-1189 | 1 |
| Foot | 5041-9167 | 4 |
| Trim, front frame side | 5041-9173 | 2 |
| Trim, top | 5041-9176 | 1 |
| Front Cap, strap handle | 5041-9186 | 2 |
| Rear Cap, strap handle | 5041-9187 | 2 |
| Standoff, rear panel | 5041-9188 | 4 |
| Handle, Strap | 5063-9210 | 2 |
| Front Handle Kit | 5063-9228 | 1 |
| Rack Mount Kit | 5063-9235 | 1 |
| Parallel Cable | 8120-6818 | 1 |
| Jumper Cable | 5062-6682 | 2 |
| LCD Cable | 8120-8794 | 1 |
| Assembly, switch | 08711-60129 | 1 |
| Rear Panel | 08720-00102 | 1 |
| Bracket, switch | 08720-00103 | 3 |
| RF Cable J53(59)-1 | 08720-20189 | 2 |
| RF Cable J51(57)-2 | 08720-20194 | 2 |
| RF Cable J12-2 to J11-6 | 08720-20206 | 1 |
| RF Cable J12-6 to J11-2 | 08720-20207 | 1 |
| RF Cable Odd FP Ports | 08720-20235 | 6 |
| Wire Harness, multiport ¹ | 08720-60191 | 1 |
| Switch Support, 12 sw | 87050-00020 | 1 |
| Deck | 87050-00021 | 1 |
| RF Cable, J50(56)-1 ¹ | 87050-20131 | 2 |

Table 4-1 **Replaceable Parts (Continued)**

| Replacement Part | Part Number | Quantity |
|---|--------------------------------|----------|
| RF Cable, J51(57)-1 ¹ | 87050-20132 | 2 |
| RF Cable, J52(58)-1 ¹ | 87050-20133 | 2 |
| RF Cable, J54(60)-1 ¹ | 87050-20134 | 2 |
| RF Cable, J55(61)-1 ¹ | 87050-20135 | 2 |
| RF Cable, J50(56)-2 ¹ | 87050-20136 | 2 |
| RF Cable, J52(58)-2 ¹ | 87050-20137 | 2 |
| RF Cable, J53(59)-2 ¹ | 87050-20138 | 2 |
| RF Cable, J54(60)-2 ¹ | 87050-20139 | 2 |
| RF Cable, J55(61)-2 ¹ | 87050-20140 | 2 |
| RF Cable, Reflection Port ¹ | 87050-20141 | 1 |
| RF Cable, Transmission Port ¹ | 87050-20142 | 1 |
| RF Cable, SW10-1 to SW50-2, SW11-1 to SW56-2 ¹ | 87050-20145 | 4 |
| RF Cable, SMA (f) to SMA (m) | 87050-20345 | 2 |
| RF Cable, N (m) to SMA (m) | 87050-20346 | 2 |
| RF Cable Even FP Ports | 87050-20347 | 6 |
| Wire Harness, 04c, 0.3m, 13f-06f | 87130-60021 | 1 |
| Wire Harness, 04c, 0.13m, 04f-04f | 87050-60022 | 1 |
| Wire Harness, 40c, 0.09m, 40f-40f | 87050-60023 | 3 |
| Fan Assembly 5 cfm | 87050-60027 | 1 |
| Daughter Control Board | 87050-60324 | 1 |
| Ribbon Cable, 16c 16f/16f | 87050-60055 | 8 |
| Controller Mother Board ¹ | 87050-60175 | 1 |
| Front Panel Subassembly ¹ | 87050-60179 | 1 |
| User's and Service Guide ¹ | 87050-90102 | 1 |
| Bracket, fan | 87075-00005 | 1 |
| Switch, 1p4t 26.5 | 87104-60001 | 2 |
| Switch, 1p6t 26.5 | 87106-60009 | 6 |
| Cable Assembly, ac line | 87130-60007 | 1 |
| Power Cord | See Figure 3-3 | 1 |

1. The parts indicated (1) are unique to this special option. To order replacement parts, please contact the Component Test PGU at (707) 577-6802 with the part number, module/model number and option number. If ordering parts through your local Agilent Technologies sales or service office, specify that they are ordered through the Component Test PGU.

NOTE Special options are built to order, therefore long lead times may be encountered when ordering replacement parts.

NOTE Before replacing an assembly or board, inspect for obvious, easily repaired defects such as bent pins on ICs or cold solder joints.

Troubleshooting

This section contains information on troubleshooting the test set to the assembly level only. By following these procedures you should be able to determine whether the power supply, front panel, or main switch board need replacing. A block diagram is included at the end of this section as an aid in troubleshooting.

The theory of operation information can be found starting on [page 63](#).

General Troubleshooting Notes

| | |
|----------------|--|
| WARNING | Always turn the instrument power off before removing or installing an assembly. |
|----------------|--|

| | |
|-------------|--|
| NOTE | If you need to disassemble the instrument, be sure to work at an antistatic workstation and use a grounded wrist strap to prevent damage from electrostatic discharge (ESD). See Figure 1-4 on page 15 . |
|-------------|--|

Troubleshooting Power Supply Problems

Turn the instrument on. Check the condition of the LCD on the front panel:

1. If the LCD is off, check the main fuse located in the power supply filter at the rear of the instrument. Refer to [Figure 3-4 on page 38](#).
2. If the fuse is in working order and the LCD is still off, check the cable and connections between the main board and front panel board.
3. If the cable and connections are working and the LCD is still off, there is still a possibility that the power supply is not supplying the necessary +24 V, +12 V, and +5 V to the main board.

Disconnect the dc power cable from the power supply to the main switch board and measure the voltages. They should be +24 V, +12 V, and +5 V. If not, replace the power supply.

Troubleshooting the Front Panel Display Board

Turn the instrument power on and check the following:

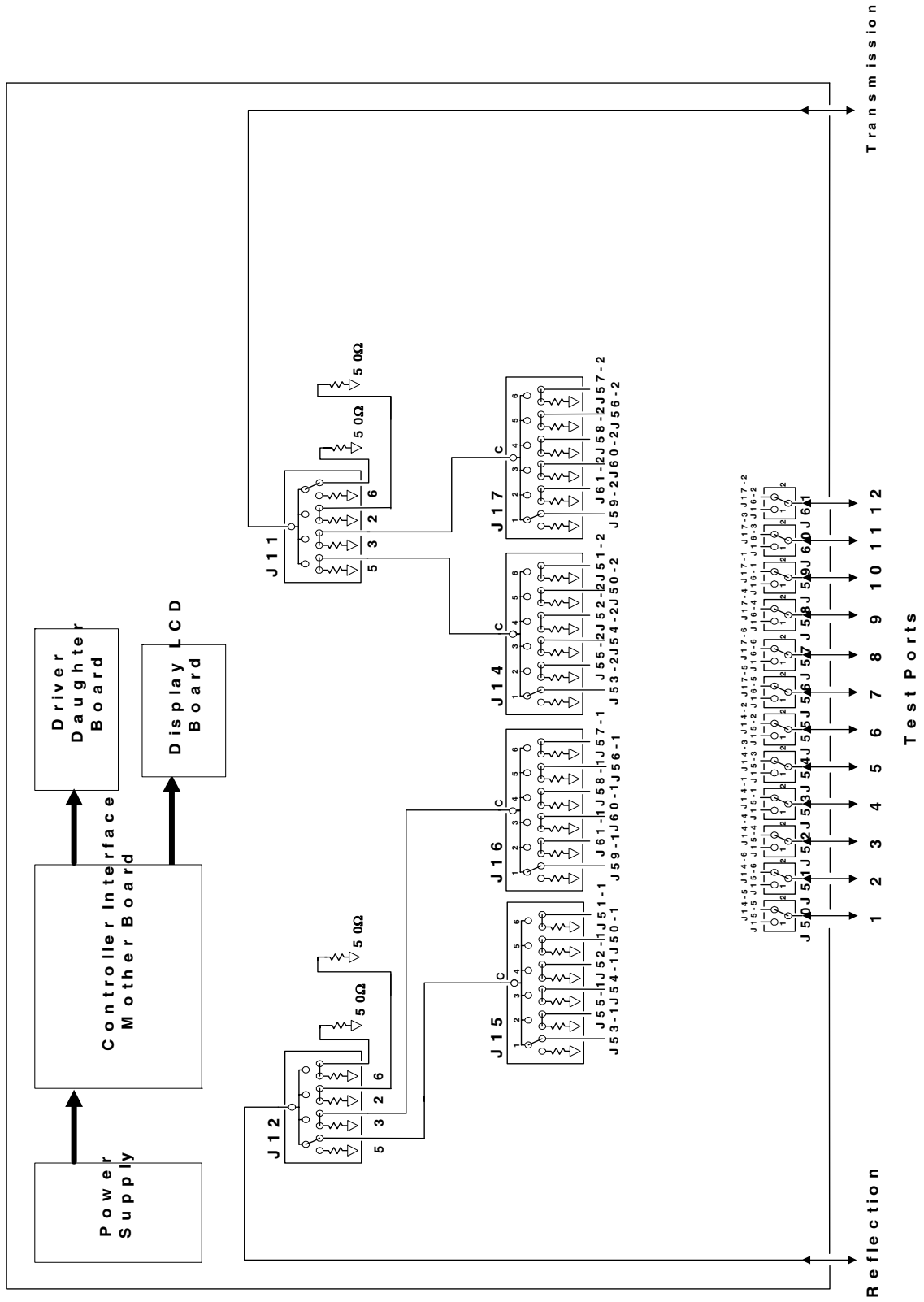
1. Check the condition of each of the switching paths by issuing commands to switch each of the paths to either the transmission or reflection path. Ensure that the LCD indicates the appropriate path.
2. If the LCD indicates a wrong path, the problem can lie with either the daughter board or the main switch board. Determine where the problem is by measuring the RF path and the +24 V control voltage.
3. If the LCD does not display the proper path, check to see if the RF path has been switched. If the problem lies with the daughter board, replace it.

Troubleshooting the Controller and Switch Driver Boards

Turn On the instrument power. Check the condition of each of the switching paths by issuing commands to switch each of the paths to either the transmission or reflection path. Check each of the RF paths for connection. If an RF path is not connected to the necessary port or terminated in 50Ω, replace the controller and switch driver board.

Refer to [Figure 4-1 on page 62](#) for a block diagram of the major components and the switching paths of the 87050A Option K12.

Figure 4-1 87050A Option K12 Block Diagram



Theory of Operation

The theory of operation begins with a general description of the 87050A Option K12 multiport test set. This is followed by more detailed operating theory. The operation of each group is described briefly, to the assembly level only. Detailed component level circuit theory is not provided.

System Theory

The test set consists of three main components: a power supply, a front panel display, and a controller interface mother board. The purpose of the power supply is to provide power to both the front panel display and the main switch board. The front panel display serves to indicate the switching paths to the user. Finally, the controller interface mother board does the actual switching between the different ports.

A1 Power Supply Theory

The switching power supply provides regulated dc voltages to power all assemblies in the test set. A dc cable provides power to the main switch board. A connector from the main switch board to the front panel display provides dc power and control signals to the front panel. The power supply provides the following supplies: +24 V, +12 V, and +5 V.

A2 Front Panel Display Theory

The front panel display consists of an LCD. The LCD is divided into a reflection line and a transmission line. The reflection line indicates which one of the sixteen ports is connected to the REFLECTION port. The transmission line indicates which one of the sixteen ports is connected to the TRANSMISSION port. Control signals and dc power are provided by a cable connected to the main switch board.

A3 Controller Board and Switch Driver Board Theory

Refer to [Figure 4-1 on page 62](#) for the following discussion.

The mother board (controller board) and daughter board (switch driver board) provide the bias for the switching paths for the various test ports to the TRANSMISSION and REFLECTION ports. The front panel display contains an LCD that indicates the switched ports. A particular test port (1 through 12) can be in one of three states. The three states are:

1. switched to the forward path
2. switched to the reverse path
3. terminated in 50Ω

When a port is not connected it is automatically terminated in 50Ω .

The test set consists of twelve 1-by-2 switches, four 1-by-6 switches, and two 1-by-4 switches. The 1-by-2 switches divide each of the input ports (1 through 12) into two separate paths, the transmission path or the reflection path.

Each path, transmission or reflection, is routed to a bank of two 1-by-6 switches. Each bank of switches is routed to a single 1-by-4 switch, where it becomes either the TRANSMISSION port or the REFLECTION port.

All switches are mechanical and are biased according to the necessary switching path. A user interface, through the GPIB and parallel ports, converts the necessary input signals to the control signals, which then control the switching paths.

Safety and Regulatory Information

Introduction

Review this product and related documentation to familiarize yourself with safety markings and instructions before you operate the instrument. The documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

Connector Care and Cleaning

If alcohol is used to clean the connectors, the power cord to the instrument must be removed. All cleaning should take place in a well ventilated area. Allow adequate time for the fumes to disperse and moist alcohol to evaporate prior to energizing the instrument.

Before Applying Power

Verify that the product is configured to match the available main power source. If this product is to be powered by autotransformer, make sure the common terminal is connected to the neutral (grounded) side of the ac power supply.

Shipping Instructions

You must always call the Agilent Technologies Instrument Support Center to initiate service before retuning your instrument to a service office. See [“Contacting Agilent” on page 70](#). Always transport or ship the instrument using the original packaging if possible. If not, comparable packaging must be used. Attach a complete description of the failure symptoms.

Statement of Compliance

This instrument has been designed and tested in accordance with IEC Publication 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, and has been supplied in a safe condition. The instruction documentation contains information and warnings which must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

Warnings

WARNING **“WARNING”:** Warning denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning note until the indicated conditions are fully understood and met.

Warnings applicable to this instrument are:

WARNING **If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**

WARNING **No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.**

WARNING **For continued protection against fire hazard, replace line fuse only with same type and rating. The use of other fuses or materials is prohibited.**

WARNING **This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted into a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.**

WARNING **The power cord is connected to internal capacitors that may remain live for 5 seconds after disconnecting the plug from its power supply.**

WARNING **These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**

WARNING **The opening of covers or removal of parts is likely to expose dangerous voltages. Disconnect the product from all voltage sources while it is being opened.**

WARNING **To prevent electrical shock, disconnect the Agilent Technologies model 87050A Option K12 from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

Cautions

CAUTION CAUTION: Caution denotes a hazard. It calls attention to a procedure that, if not correctly performed or adhered to, could result in damage to or destruction of the product. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.

Cautions applicable to this instrument are:












CAUTION Always use the three-prong ac power cord supplied with this instrument. Failure to ensure adequate earth grounding by not using this cord may cause instrument damage.

CAUTION This instrument has autoranging line voltage input. Be sure the supply voltage is within the specified range.

CAUTION This product is designed for use in Installation Category II and Pollution Degree 2 per IEC 1010 and 664 respectively.

CAUTION **Ventilation Requirements:** When installing the instrument in a cabinet, the convection into and out of the instrument must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the instrument by $4 \times ^\circ\text{C}$ for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, then forced convection must be used.

Instrument Markings

| | |
|---|---|
|  | When you see this symbol on your instrument, you should refer to the instrument's instruction manual for important information. |
|  | This symbol indicates hazardous voltages. |
|  | The laser radiation symbol is marked on products that have a laser output. |
|  | This symbol indicates that the instrument requires alternating current (ac) input. |
|  | The CE mark is a registered trademark of the European Community. If it is accompanied by a year, it indicates the year the design was proven. |
|  | The CSA mark is a registered trademark of the Canadian Standards Association. |
|  | This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPR 11, Clause 4). |
|  | This symbol indicates that the power line switch is ON. |
|  | This symbol indicates that the power line switch is OFF or in STANDBY position. |
|  | This symbol indicates the product meets the Australian Standards. |
|  | Safety Earth Ground. This is a Safety Class I product (provided with a protective earthing terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and secured against any unintended operation. |

Contacting Agilent

By internet, phone, or fax, get assistance with all your test and measurement needs.

| | | | |
|--|---|---|--|
| This information supersedes all prior HP contact information. | | | |
| Online assistance: www.agilent.com/find/assist | | | |
| Americas | | | |
| Brazil (tel) (+55) 11 3351 7012 (fax) (+55) 11 3351 7024 | Canada (tel) +1 877 894 4414 (fax) +1 303 662 3369 | Mexico (tel) 1 800 254 2440 (fax) 1 800 254 4222 | United States (tel) 800 829 4444 (alt) (+1) 303 662 3998 (fax) 800 829 4433 |
| Asia Pacific and Japan | | | |
| Australia (tel) 1 800 225 574 (fax) 1 800 681 776 (fax) 1 800 225 539 | China (tel) 800 810 0508 (alt) 800 810 0510 (fax) 800 810 0507 (fax) 800 810 0362 | Hong Kong (tel) 800 933 229 (fax) 800 900 701 | India (tel) 1600 112 626 (fax) 1600 112 727 (fax) 1600 113 040 |
| Japan (Bench) (tel) 0120 32 0119 (alt) (+81) 426 56 7799 (fax) 0120 01 2144 | Japan (On-Site) (tel) 0120 802 363 (alt) (+81) 426 56 7498 (fax) (+81) 426 60 8953 | Singapore (tel) 1 800 275 0880 (fax) (+65) 6755 1235 (fax) (+65) 6755 1214 | South Korea (tel) 080 778 0011 (fax) 080 778 0013 |
| Taiwan (tel) 0800 047 669 (fax) 0800 047 667 (fax) 886 3492 0779 | Thailand (tel) 1 800 2758 5822 (alt) (+66) 2267 5913 (fax) 1 800 656 336 | Malaysia (tel) 1800 880 399 (fax) 1800 801 054 | |
| Europe | | | |
| Austria (tel) 0820 87 44 11* (fax) 0820 87 44 22 | Belgium (tel) (+32) (0)2 404 9340 (alt) (+32) (0)2 404 9000 (fax) (+32) (0)2 404 9395 | Denmark (tel) (+45) 7013 1515 (alt) (+45) 7013 7313 (fax) (+45) 7013 1555 | Finland (tel) (+358) 10 855 2100 (fax) (+358) (0) 10 855 2923 |
| France (tel) 0825 010 700* (alt) (+33) (0)1 6453 5623 (fax) 0825 010 701* | Germany (tel) 01805 24 6333* (alt) 01805 24 6330* (fax) 01805 24 6336* | Ireland (tel) (+353) (0)1 890 924 204 (alt) (+353) (0)1 890 924 206 (fax) (+353) (0)1 890 924 024 | Israel (tel) (+972) 3 9288 500 (fax) (+972) 3 9288 501 |
| Italy (tel) (+39) (0)2 9260 8484 (fax) (+39) (0)2 9544 1175 | Luxemburg (tel) (+32) (0)2 404 9340 (alt) (+32) (0)2 404 9000 (fax) (+32) (0)2 404 9395 | Netherlands (tel) (+31) (0)20 547 2111 (alt) (+31) (0)20 547 2000 (fax) (+31) (0)20 547 2190 | Russia (tel) (+7) 095 797 3963 (alt) (+7) 095 797 3900 (fax) (+7) 095 797 3901 |
| Spain (tel) (+34) 91 631 3300 (alt) (+34) 91 631 3000 (fax) (+34) 91 631 3301 | Sweden (tel) 0200 88 22 55* (alt) (+46) (0)8 5064 8686 (fax) 020 120 2266* | Switzerland (French) (tel) 0800 80 5353 opt. 2* (alt) (+33) (0)1 6453 5623 (fax) (+41) (0)22 567 5313 | Switzerland (German) (tel) 0800 80 5353 opt. 1* (alt) (+49) (0)7031 464 6333 (fax) (+41) (0)1 272 7373 |
| Switzerland (Italian) (tel) 0800 80 5353 opt. 3* (alt) (+39) (0)2 9260 8484 (fax) (+41) (0)22 567 5314 | United Kingdom (tel) (+44) (0)7004 666666 (alt) (+44) (0)7004 123123 (fax) (+44) (0)7004 444555 | | |
| (tel) = primary telephone number; (alt) = alternate telephone number; (fax) = FAX number; * = in country number 11/16/04 | | | |