Instruction Manual

Model 7016
50Ω GHz Multiplexer Card

Contains Operating and Servicing Information

KEITHLEY

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

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Model 7016 50Ω GHz Multiplexer Card
Instruction Manual

Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number (7016-901-01) .... March 1995

Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture rear panel, or switching card.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC main. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a ⏚ screw is present, connect it to safety earth ground using #18 AWG or larger wire.

The ⚡ symbol on an instrument or accessory indicates that 1000V or more may be present on the terminals. Refer to the product manual for detailed operating information.

Instrumentation and accessories should not be connected to humans.

Maintenance should be performed by qualified service personnel. Before performing any maintenance, disconnect the line cord and all test cables.
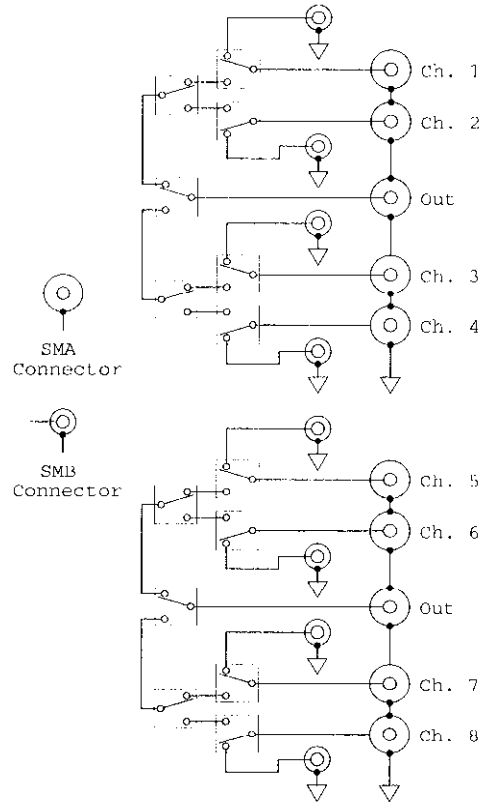
SPECIFICATIONS

MULTIPLEXERS PER CARD: 2 (with isolated ground).

CHARACTERISTIC IMPEDANCE: 50Ω nominal.

CHANNELS PER MULTIPLEXER: 4.

CONTACT CONFIGURATION: 1 pole Form A, common shield.

RELAY DRIVE CURRENT: <144mA per channel.

CONNECTOR TYPE: SMA.

RECOMMENDED CABLE: RG-223/U.

TERMINATION: User supplied 50Ω SMB termination (on unselected inputs).

ACTUATION TIME: 8ms.

MAXIMUM VOLTAGE: Any terminal (center or shield) to any other terminal or chassis: 30V.

MAXIMUM CURRENT: 0.5A per channel.

MAXIMUM POWER: 10VA switched up to 1.3GHz.

ISOLATION:

Multiplexer to Multiplexer:	>1GΩ.
Center to Shield:	>1GΩ, <60pF.
Channel to Channel:	>100MΩ.

RISE TIME: <300ps.

SIGNAL DELAY: <3ns; channels matched to 50ps.

CONTACT POTENTIAL: <6μV.

CONTACT RESISTANCE: <1Ω.

CONTACT LIFE: 1×10^5 closures

ENVIRONMENT: Operating: 0° to 50°C, up to 35°C at <80% RH.
Storage: –25° to 65°C.

AC PERFORMANCE:

For ZL = ZS = 50Ω	≤10 MHz	≤100 MHz	≤500 MHz	≤900 MHz	≤1.2 GHz	≤1.3 GHz
Insertion Loss (dB):	<0.3	<0.7	<1.1	<2.0	<3.0	<3.0
Crosstalk (dB)[1]						
Channel-Channel	<–90	<–80	<–65	<–55	<–55	<–55
Mux. to Mux.	<–90	<–80	<–70	<–65	<–60	<–60
VSWR	<1.2	<1.25	<1.35	<1.6	<1.8	<2.6

[1] Specification assumes 50Ω termination.

Specifications subject to change without notice.

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1

General Information

1.1 Introduction

This section contains general information about the Model 7016 50Ω GHz Multiplexer Card. The Model 7016 is equipped with two four-channel multiplexers and is designed for 50Ω operation. Provisions for user-supplied 50Ω terminators are provided on the card.

1.2 Features

Key Model 7016 features include:

- Two independent multiplexers each with four channels.
- 50Ω characteristic impedance.
- Provisions for user-supplied SMB terminators to maintain nominal 50Ω characteristic impedance for off channels.
- 1.3GHz bandwidth.
- Low insertion loss (<3dB @ 1.3GHz).
- Low VSWR assures good high-frequency performance.

1.3 Warranty information

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7016 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the card for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.

1.4 Manual addenda

Any improvements or changes concerning the card or manual will be explained in an addendum included with the card.

1.5 Safety symbols and terms

The following symbols and terms may be found on an instrument or used in this manual.

The $\triangle!$ symbol on equipment indicates that you should refer to the operating instructions located in the instruction manual.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the multiplexer card. Such damage may invalidate the warranty.

1.6 Specifications

Model 7016 specifications are located at the front of this manual.

1.7 Unpacking and inspection

1.7.1 Inspection for damage

The Model 7016 is packaged in a re-sealable, anti-static bag to protect it from damage due to static discharge and from contamination that could degrade its performance. Before removing the card from the bag, observe the precautions on handling discussed below.

1.7.2 Handling precautions

- Always grasp the card by the side edges and covers. Do not touch the board surfaces or components.

- After removing the card from its anti-static bag, inspect it for any obvious signs of physical damage. Report any such damage to the shipping agent immediately.

- When the card is not installed in a switching mainframe, keep the card in its anti-static bag, and store it in the original packing carton.

1.7.3 Shipment contents

The following items are included with every Model 7016 order:

- Model 7016 50Ω GHz Multiplexer Card

- Model 7016 Instruction Manual

- Additional accessories as ordered

1.8 Instruction manual

If an additional Model 7016 Instruction Manual is required, order the manual package, Keithley part number 7016-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.9 Repacking for shipment

Should it become necessary to return the Model 7016 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Advise as to the warranty status of the card.

- Write ATTENTION REPAIR DEPARTMENT on the shipping label.

- Fill out and include the service form located at the back of this manual.

1.10 Recommended accessories

Recommended cables and terminating resistors are covered below. These items are not stocked by Keithley and must be obtained from other sources.

1.10.1 Connecting cables

The following cable type is recommended for making input/output connections to the Model 7016: RG223/U.

Other 50Ω cables may be used, but keep in mind key parameters as such as maximum outside diameter, attenuation over the desired frequency range, flexibility, and shield type. See paragraph 3.5 in Section 3 for more information on cable parameters.

1.10.2 Terminating resistors

The following terminating resistor is recommended for use with the Model 7016:

Type: Female SMB terminator
Manufacturer: Sealectro Corp.
Part number: 61-001-0101
Nominal resistance: 51Ω, ±1%.
Power dissipation: 2W

2

Connections and Installation

2.1 Introduction

WARNING

The procedures in this section are intended only for qualified service personnel. Do not perform these procedures unless you are qualified to do so. Failure to recognize and observe normal safety precautions could result in personal injury or death.

This section includes information on making connections to the Model 7016 and installing the card in the Model 7001/7002 Switch System.

2.2 Handling precautions

To maintain high-impedance isolation between channels, care should be taken when handling the card to avoid contamination from such foreign materials as body oils. Such contamination can reduce isolation resistance. To avoid possible contamination, always grasp the card by the side edges or covers. Do not touch board surfaces, components, or connector insulators.

Dirt build-up over a period of time is another possible source of contamination. To avoid this problem, operate the card in a clean environment. If the card becomes contaminated, it should be thoroughly cleaned as explained in paragraph 4.2.

2.3 Connections

This paragraph provides the information necessary to connect your external test circuitry to the Model 7016.

2.3.1 Simplified schematic

Figure 2-1 shows a simplified schematic diagram of the Model 7016. The card is arranged into two separate multiplexers, each with four channels.

2.3.2 Card configuration

Figure 2-2 shows the general configuration of the Model 7016. Connectors include:

IN 1-8 (channels 1-8): Each input is equipped with an SMA coaxial connector. The center conductor is the signal path, while the outer shell connected to signal common.

OUT A and OUT B: Each multiplexer is equipped with an SMA coaxial connector. The center conductor is the signal path, and the shell is connected to signal common.

Termination jacks: Each channel has an SMB coaxial terminator jack. User-supplied 50Ω terminators can be connected to these jacks when a 50Ω nominal input impedance must be maintained for off channels.
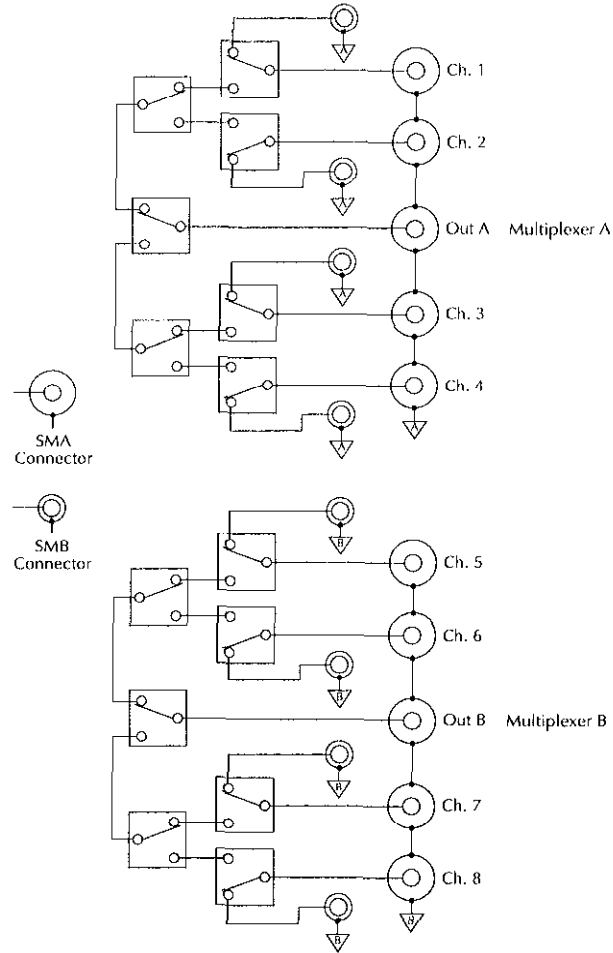
Figure 2-1
Model 7016 simplified schematic
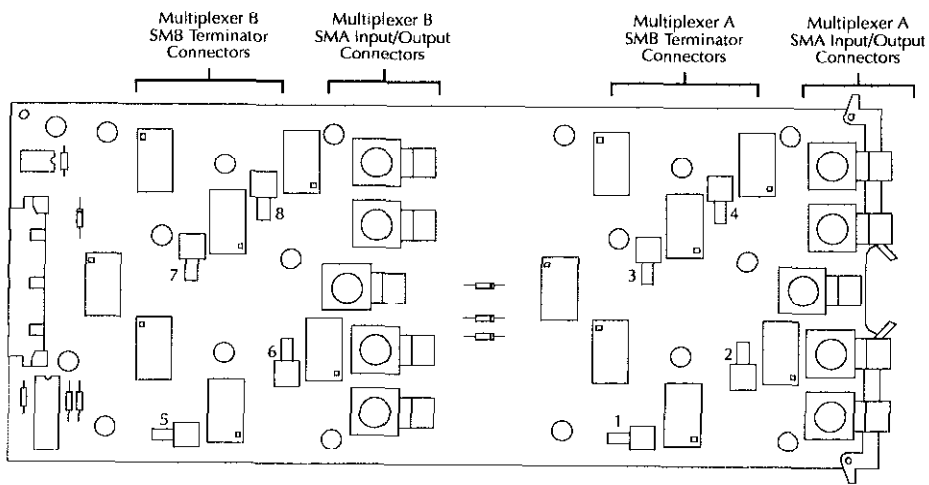
Figure 2-2
Model 7016 configuration

2.3.3 Input/output connecting cables

All connections to the scanner card input and output jacks should be made using 50Ω coaxial cable equipped with SMA connectors. The recommended cable type is RG223/U.

WARNING

Make sure that power is off and external energy sources are discharged before connecting or disconnecting cables.

NOTE

50Ω cables must be used to assure good high-frequency performance. RG223/U should be used for best performance. See

paragraph 3.5 in Section 3 for more information.

2.3.4 Typical connecting scheme

Figure 2-3 shows a typical connecting scheme for the Model 7016. In this arrangement, sources are connected to the inputs while the measuring instrument is connected to the outputs.

CAUTION

Maximum voltage from any terminal (center conductor or shield) to any other terminal or chassis is 30V RMS. Exceeding this value may result in card damage.
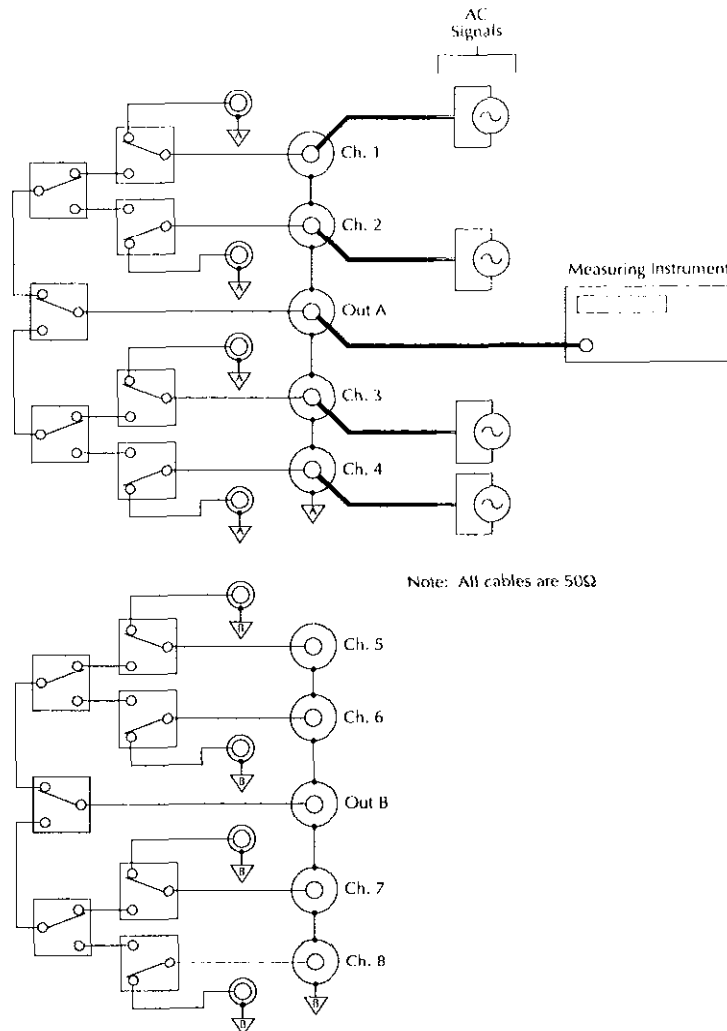
Figure 2-3
Typical connection scheme

2.3.5 Input termination

User-supplied 50Ω female SMB terminators may be installed for applications requiring proper 50Ω termination of off channels. Figure 2-4 shows typical installation of a 50Ω terminator. See paragraph 1.10 in Section 1 for recommended terminators. Switching considerations in Section 3 discusses terminator aspects in more detail.

NOTE

Be sure to observe the maximum power handling capability of installed terminators. The terminators recommended in Section 1 are limited to 2W even through the Model 7016 can switch up to 10W.

2.4 Card installation and removal

This paragraph explains how to install and remove the Model 7016 card assembly from the Model 7001/7002 mainframe.

WARNING

Installation or removal of the Model 7016 should be performed only by qualified service personnel. Failure to recognize and observe standard safety precautions could result in personal injury or death.

NOTE

To prevent performance degradation caused by contamination, handle the card only by the edges and covers.
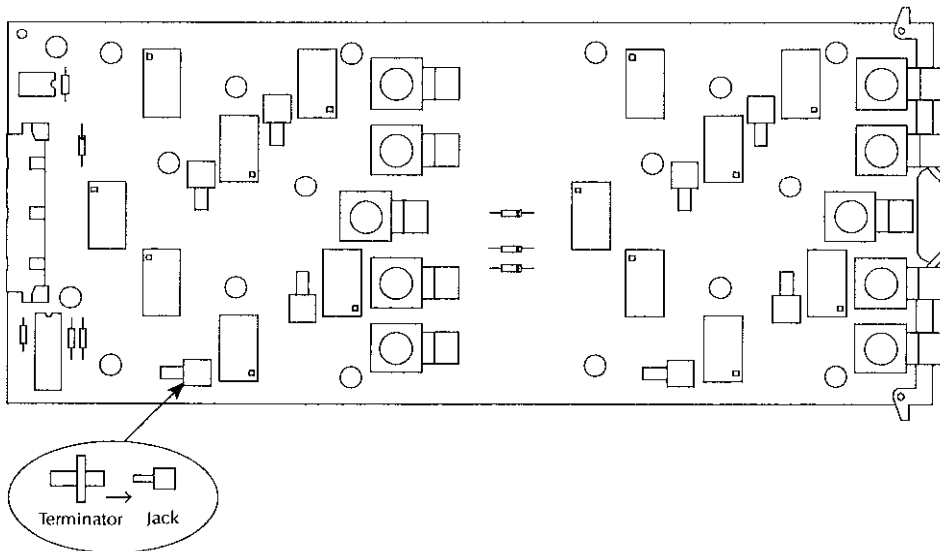
Figure 2-4
50Ω terminator installation

2.4.1   Card installation

Perform the following steps, and refer to Figure 2-5 or Figure 2-6 to install the card assembly in the Model 7001/7002 mainframe.

WARNING

Turn off power to all instrumentation (including the Model 7001/7002), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.

1. Open the ejector arms at the back edge of the card.
2. Slide the card edges into the guide rails inside the mainframe.
3. Carefully push the card all the way forward until the ejector arms engage the mounting cups.
4. Push in on the card edge and ejector arms until the card is properly seated.
5. Make sure the ejector arms are properly latched.

2.4.2   Card removal

Follow the steps below to remove the multiplexer card from the mainframe:

WARNING

Turn off power to all instrumentation (including the Model 7001/7002), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.

1. Pull out on the ejector arms until the card pulls free from the internal connector.
2. Carefully slide the card out of the switching mainframe.
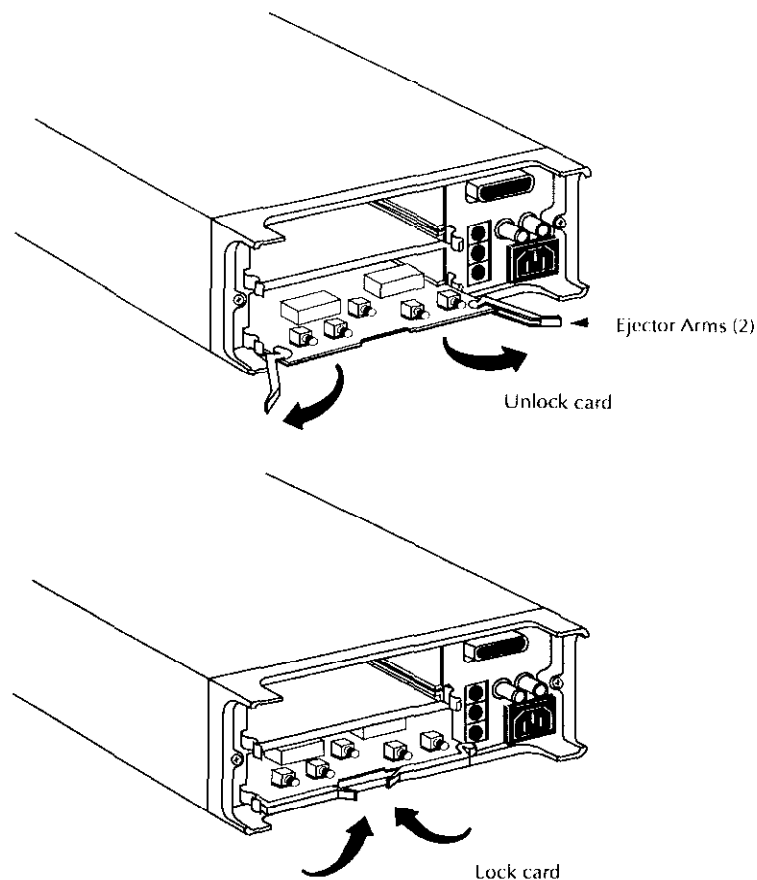
Figure 2-5
Card installation in Model 7001
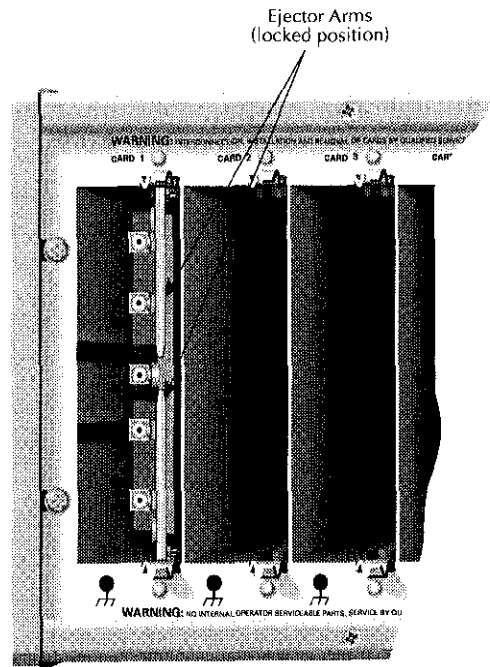
Figure 2-6
Card installation in Model 7002

3

Operation

3.1 Introduction

This section contains basic information on using the Model 7016 including signal limitations and switching considerations. For detailed mainframe operating information, refer to the Model 7001 or Model 7002 Instruction Manual.

3.2 Signal limitations

CAUTION

To prevent damage to the Model 7016, do not exceed the maximum signal level specifications of the card.

To prevent over-heating or damage to the relays, never exceed the following maximum signal levels when using the Model 7016:

- Maximum voltage: Any center conductor or shield to any other center conductor or to chassis: 30V.
- Maximum current: 0.5A per channel.
- Maximum power: 10VA switched up to 1.2GHz.

3.3 Front panel control

3.3.1 Closing and opening channels

To close a Model 7016 multiplexer channel, simply key in the CHANNEL assignment (1-8), then press the Model 7001/7002 CLOSE key. For example, to close channel 4 of a Model 7016 installed in slot 2, key in the following channel list, and press CLOSE:

SELECT CHANNELS 2!4

To open a closed channel, simply press OPEN or OPEN ALL.

Channels are organized into two multiplexer banks as follows:

Multiplexer A: channels 1 to 4
Multiplexer B: channels 5 to 8

You can also simultaneously close one channel in each multiplexer by including both channels in the channel list. For example, to close channels 1 and 5 of a card in slot 1, enter the following channel list at the prompt:

SELECT CHANNELS 1!1, 1!5

(Note that channels are separated by a comma, which can be inserted by pressing either the ENTER or right cursor key.)

NOTE

To maintain 50Ω characteristic impedance, close only one channel per multiplexer simultaneously. Closing more than one channel per multiplexer may cause unexpected results. Program the Model 7001/7002 for restricted operation to avoid closing more than one channel at a time.

Again, you can open closed channels with the OPEN or OPEN ALL key. (OPEN opens only channels in the channel list while OPEN ALL opens all channels.)

3.3.2 Scanning channels

To scan through channels, first configure a scan list, then program the Model 7001/7002 to perform a scan sequence. You can create a scan list in the same manner as you would a channel list. First, however, press the SCAN LIST key to select the "SCAN CHANNEL" mode, then enter the desired channels to be included in the scan list. For example, the following list scans channels 1, 3, and 5 through 8 of a Model 7016 installed in slot 2:

SCAN CHANNELS 2!1, 2!3, 2!5-2!8

Note that channels are scanned in the order they appear in the scan list.

To perform a manual scan, first select the RESET default conditions in the SAVESETUP menu of the main MENU. Press STEP to take the mainframe out of the idle state, then manually scan through channels by pressing the STEP key.

For information on more complex scan sequences, refer to the Model 7001 or 7002 Instruction Manual.

3.4 IEEE-488 bus control

3.4.1 Closing and opening channels

Use the following SCPI commands to close and open channels:

:CLOS <list>
:OPEN <list> | ALL

For example, the following command will close channels 2 and 6 of a Model 7016 installed in slot 1:

:CLOS (@ 1!2, 1!6)

Conversely, either of the commands below will open previously closed channels 2 and 6:

:OPEN (@ 1!2, 1!6)
:OPEN ALL

3.4.2 Scanning channels

There are a number of commands associated with scanning. However, you can perform a simple scan using only the following four commands:

*RST
:TRIG:SEQ:COUN:AUT ON
:ROUT:SCAN <list>
:INIT

The *RST command selects the default scan configuration, while the second command automatically sets the channel count to the number of channels in the scan list. The :ROUT:SCAN command programs the scan list, and the :INIT command takes the mainframe out of the idle state.

For example, send the following commands to scan through all eight channels of a Model 7016 installed in slot 1:

*RST
:TRIG:SEQ:COUN:AUT ON
:ROUT:SCAN (@ 1!1:1!8)
:INIT

3.5 Switching considerations

Signals passing through the Model 7016 50Ω GHz Multiplexer Card are subject to various effects that can influence their characteristics. The following paragraphs discuss some of these effects and ways to minimize them.

3.5.1 Card characteristics

Insertion loss: Insertion loss indicates signal power lost while passing through the card. This loss occurs in the various signal path components through the card (connectors, PC board traces, and relays). The amount of power lost will, of course, depend on the particular insertion loss specification as well as the applied power. For example, with an insertion loss of 1dB, and a 10W source signal applied to the card, about 2W will be dissipated in the card, and approximately 8W will appear at the load. Note that, as with most transmission lines, Model 7016 insertion loss values increase with increasing frequency.

Capacitance: Model 7016 capacitance values are sufficiently small to be of little concern in most applications. In some applications (primarily with pulse signals where capacitance can affect rise times), capacitance may be a factor. Typical Model 7016 center-to-shield capacitance is 60pF.

Crosstalk: Crosstalk figures indicate the amount of signal leakage between channels or switches on the card. With similar power levels applied to the various channels, crosstalk will be of little consequence. With widely different power levels, however, crosstalk may produced undesired results. For example, assume that 10W is applied to channel 1, and 1mW is applied to channel 2. Assuming a -55dB crosstalk figure, the unwanted signal coupled from channel 1 to channel 2 will be only 15dB below the desired channel 2 signal.

VSWR: The term VSWR (Voltage Standing Wave Ratio) is defined as the ratio of the maximum and minimum voltages along a transmission path, and it indicates the degree of impedance mismatch. In a perfectly match system, the VSWR is 1, while open and shorted paths have infinite VSWR values. Since VSWR is related to both the return loss and reflection coefficient, VSWR figures indicate the degree of signal loss and reflection; the lower the VSWR figure, the less signal attenuation that occurs along the transmission path.

Path isolation resistance: The path isolation resistance is simply the equivalent resistance between two given connecting points on the card and is of importance primarily for DC and low-frequency AC signals switched by the card. The effects of this characteristic depend on the particular isolation specification. Center-to-shield isolation resistance, for example, may cause loading problems with signals having high source resistance. Channel-to-channel isolation resistance may result in leakage currents generated in one channel caused by a voltage source connected to another channel.

3.5.2 Cable characteristics

Characteristic impedance (Z_O): Characteristic impedance is the value of cable impedance obtained by an RF measurement at either end. For example, a cable with a 50Ω characteristic impedance is equivalent to a 50Ω resistor with sufficient length to connect two components. (The characteristic impedance of a cable depends on the relative diameters of the inner and outer conductors, as well as on the dielectric constant of the insulating material.) Since the Model 7016 is designed to work with 50Ω cables, you must use 50Ω cables to assure proper impedance matching. (RG223/U cable is recommended.) Mismatching anywhere along the transmission path will increase VSWR and signal reflections, decrease return loss, and consequently result in signal attenuation.

Cable attenuation: Cable attenuation is analogous to insertion loss of the card itself in that it defines the degree of attenuation of the signal as it passes through the cable. Cable attenuation factors are generally given in dB per 100 ft. and increase with rising frequency. The recommended RG223/U cable has attenuation factors of 8.8dB/100 ft. @ 400MHz and 16.5dB/100 ft. @ 1GHz. Thus, with a 10W, 1GHz signal applied to 10 ft. of RG223/U, 3.16W will be dissipated in the cable, and 6.84W will be passed on to the card or load.

Cable termination: Proper cable termination is imperative to ensure maximum signal transfer and to minimize VSWR and signal reflections. In the case of Model 7016 operation, both source and load impedances should be as close to 50Ω as possible to assure optimum matching and thus maximum

power transfer. For example, if a 50Ω cable is terminated with 100Ω, the reflection coefficient is 0.33, the VSWR increases to 2, and the return loss is reduced to less than 10dB.

Proper termination of off channels may also be important in many cases. For example, a 75MHz source signal will see a 1m open cable as an RF short, a situation that could damage some equipment. To alleviate such problems, the Model 7016 has provisions for on-card installation of 50Ω SMB terminators. (See paragraph 2.3.5 in Section 2 for details on installing terminators.) Be sure to observe the power-handling capabilities of such terminators as most are limited to substantially less power than the 10W capability of the Model 7016.

Distributed capacitance: The distributed capacitance of the cable may be a factor, but generally only for pulse type signals where rise times are a consideration. The recommended RG223/U cable, for example, has a nominal distributed capacitance of 30.8pF/ft.

Cable connectors: Cable connectors are an obvious necessity to conveniently make signal connections to various points in a switching system. While connector designs are optimized for best performance, some small impedance mismatch at connecting points is virtually inevitable. For that reason, it is considered good practice to minimize the number of connectors used in a transmission path, especially at higher frequencies.

3.6 Applications

The Model 7016 is designed primarily for RF switching applications at frequencies up to 1.3GHz. The following paragraphs discuss typical RF applications for the Model 7016, including multiplexer expansion, filter testing, and device impedance testing.

3.6.1 Multiplexer expansion

The simplest way to connect the two Model 7016 multiplexers together for expansion is to use the classic "T" configuration shown in Figure 3-1. Note that this configuration results in a 1-of-8 multiplexer. Although this configuration is useful in many applications, the ideal 50Ω characteristic impedance will not be maintained. Consequently, VSWR will increase, affecting card insertion loss, particularly at higher frequencies. Also, considerable transmission path reflections will occur, an important consideration when switching pulse signals.
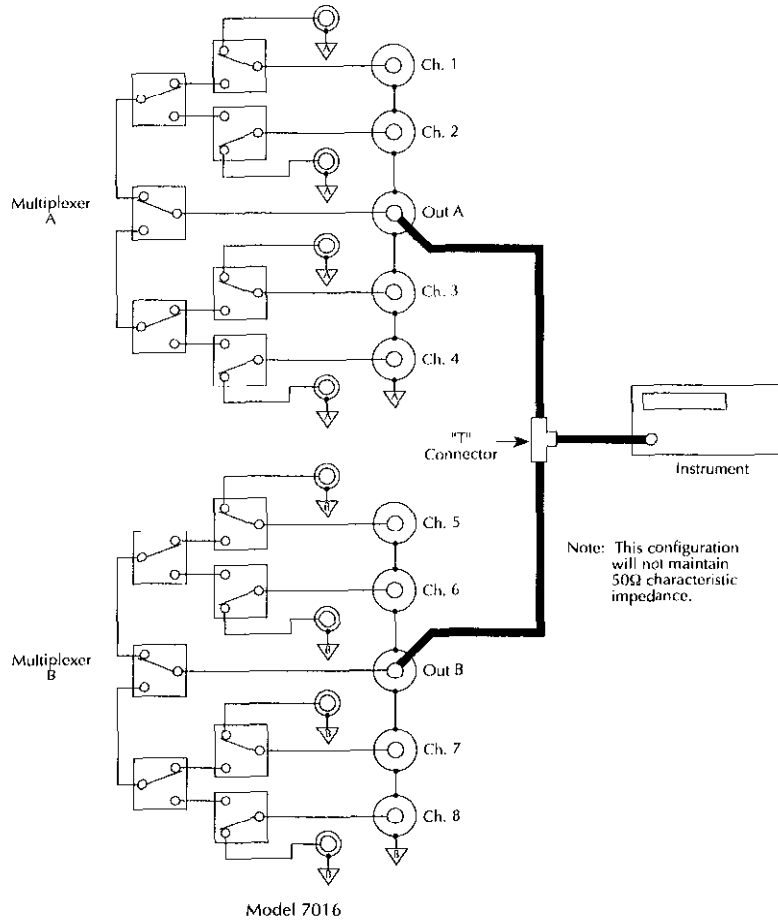
Figure 3-1
"T" connector multiplexer expansion

The proper way to connect the two Model 7016 multiplexers together is shown in Figure 3-2. Here, the two outputs are connected together using a short coaxial cable. Note that this connection scheme effectively forms a 4 × 4 matrix, and it provides a convenient way to connect four DUTs to four different test instruments. Also, this method maintains the proper 50Ω characteristic impedance for optimum bandwidth and minimal signal loss and reflections.
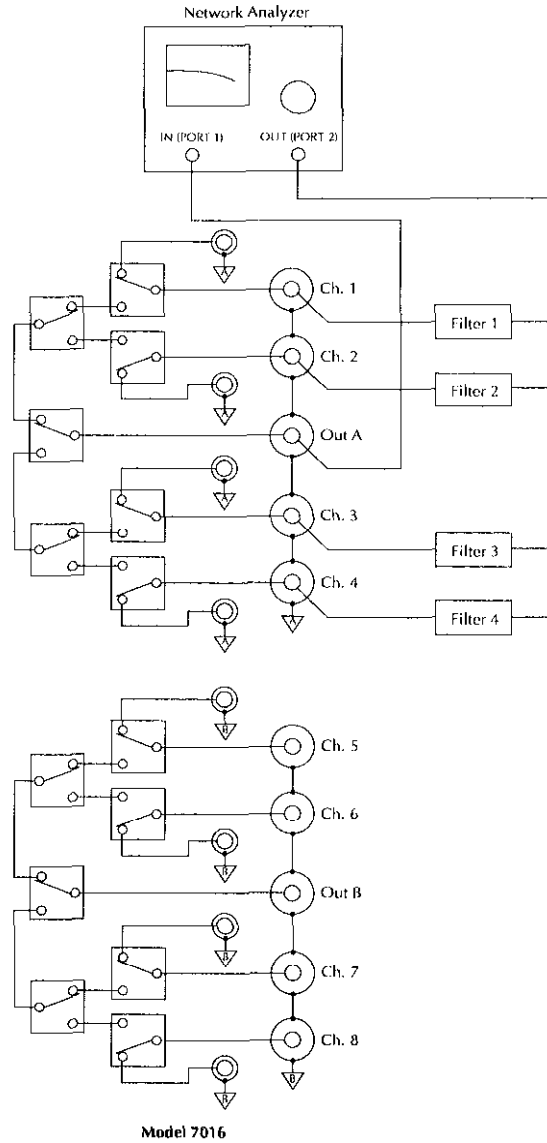

Model 7016

A. Connections

B. 4 x 4 Matrix Configuration
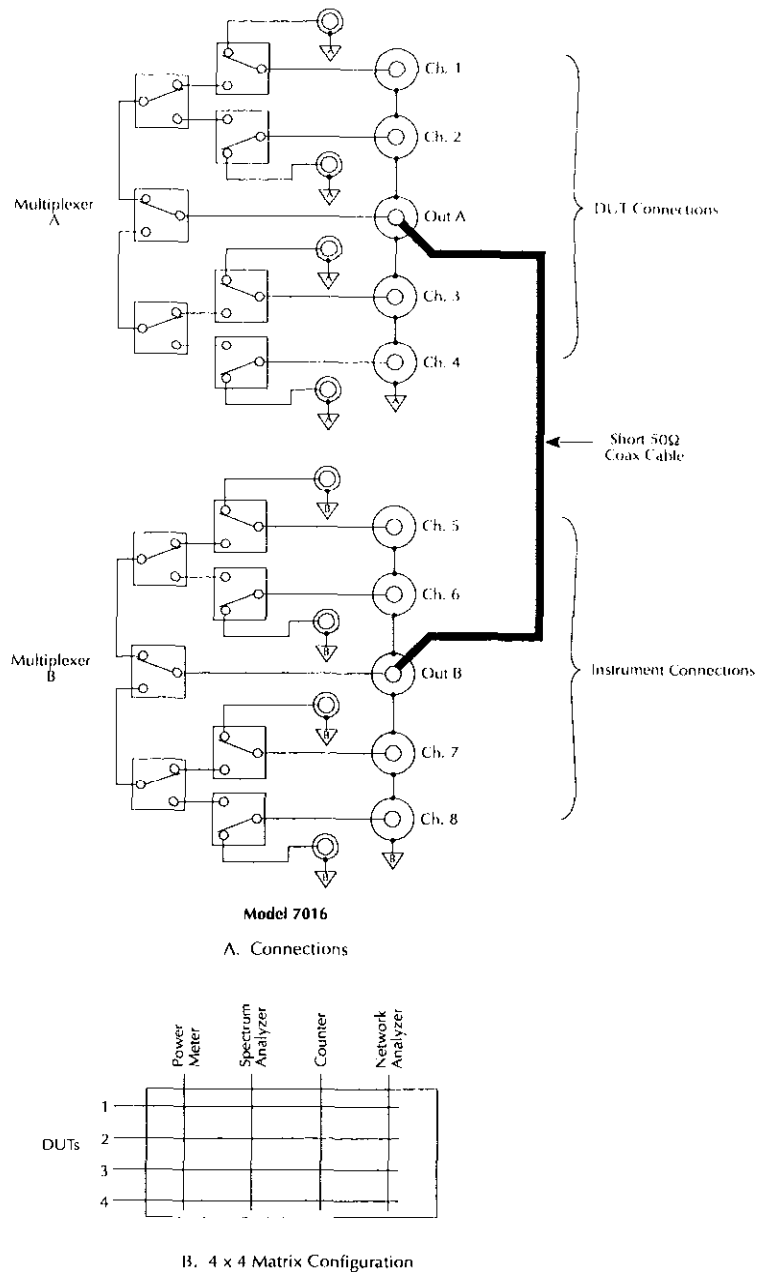
Figure 3-2
4 × 4 matrix connections

3.6.2 Filter testing

Filter frequency response and phase characteristics are key circuit parameters that often require testing. The Model 7016 may be used in conjunction with a network analyzer to test multiple filters on an automated basis.

Figure 3-3 shows a typical circuit configuration for testing four filters. Note that the network analyzer input is connected to the output of one Model 7016 multiplexers. One terminal of each DUT is connected to a corresponding Model 7016 channel, while the remaining DUT terminals are connected in common to the network analyzer output port.

The basic configuration shown in Figure 3-3 may also be used for a variety of other tests. For example, the same general scheme may be used to test amplifier S-parameters.
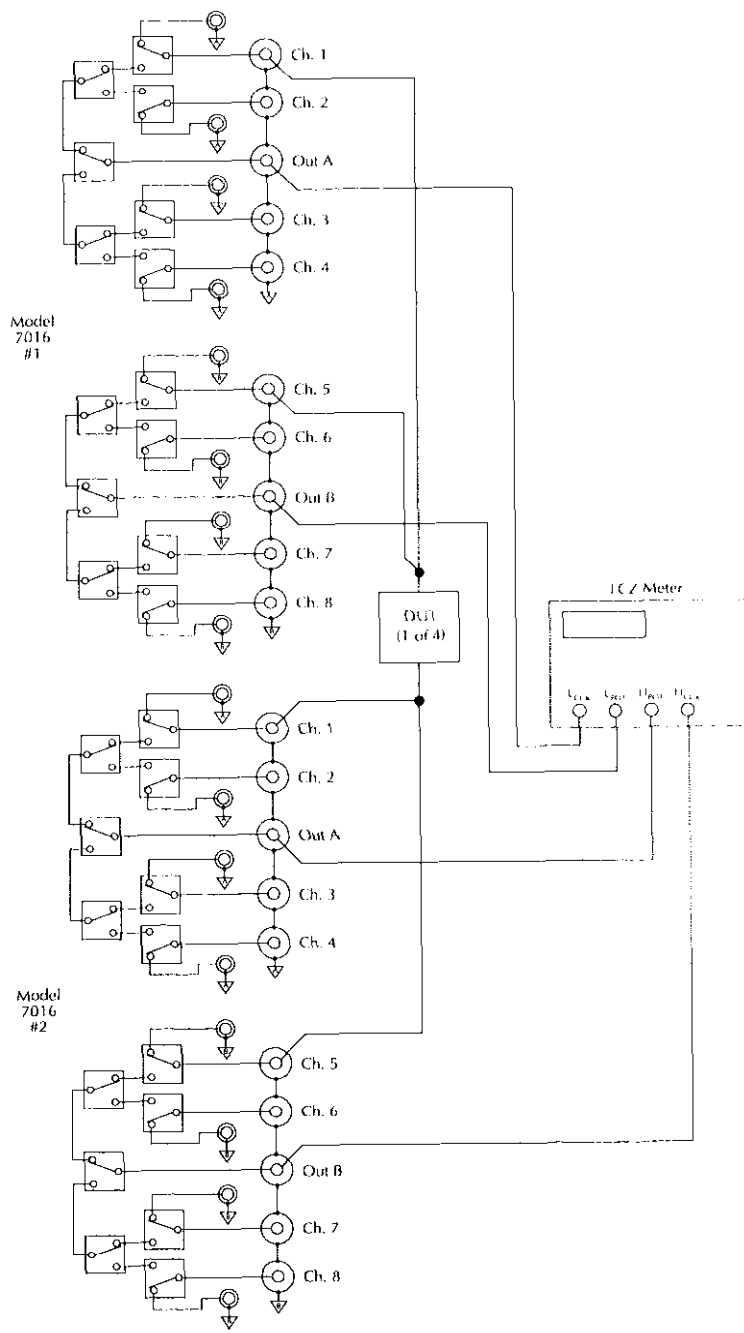
3.6.3 Impedance testing

Figure 3-4 shows the general circuit configuration for device impedance testing using the Model 7016 along with an impedance or LCZ meter, such as a Keithley Model 3321, 3322, or 3330. Since 4-wire connections are required for such measurements, two Model 7016 cards are necessary for this application. Each multiplexer switches one of the four required signal paths to the DUTs.

Since the characteristics of the Model 7016 may affect measured DUT impedance, steps should be taken to null out the residual affects of stray capacitance and inductance. Most LCZ meters have provisions for both open and short zeroing procedures to minimize these effects. For optimum accuracy, the zeroing procedure should be carried out independently for each channel.

Figure 3-3
Filter testing

Figure 3-4
Impedance testing

4

Service Information

4.1 Introduction

This section contains information necessary to service the Model 7016 and includes information on handling and cleaning, performance verification, as well as principles of operation and troubleshooting.

WARNING

The information in this section is intended only for qualified service personnel. Some of the procedures may expose you to hazardous voltages that could result in personal injury or death. Do not perform these procedures unless you are qualified to do so.

4.2 Handling and cleaning precautions

Because of the high-impedance areas on the Model 7016, care should be taken when handling or servicing the card to prevent possible contamination. The following precautions should be observed when servicing the card.

4.2.1 Handling precautions

Observe the following precautions when handling the multiplexer card:

- Handle the card only by the edges and shields.
- Do not touch connector insulators.
- Do not touch any board surfaces or components not associated with the repair.

- Do not touch areas adjacent to electrical contacts.
- When servicing the card, wear clean cotton gloves.
- Do not store or operate the card in an environment where dust could settle on the circuit board.
- Use dry nitrogen gas to clean dust off the board if necessary.

4.2.2 Soldering considerations

Should it become necessary to use solder on the circuit board, observe the following precautions:

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work areas when the repair has been completed. Use pure water along with clean cotton swabs or a clean soft brush to remove the flux.
- Once the flux has been removed, swab only the repaired area with methanol, then blow dry the board with dry nitrogen gas.
- After cleaning, allow the card to dry in a 50°C low-humidity environment for several hours before use.

4.3 Performance verification

The following paragraphs provide performance verification procedures for the Model 7016. These tests include insertion loss and isolation tests.

4.3.1 Environmental conditions

All performance verification measurements should be made at an ambient temperature of 18°C to 28°C and <70% relative humidity.

4.3.2 Recommended verification equipment

Table 4-1 summarizes the test equipment recommended for performance verification. Alternate equipment may be used as long as the corresponding specifications are at least as good as those listed.

4.3.3 Insertion loss tests

Insertion loss tests are performed by applying a 10MHz-1.3GHz signal from a network analyzer to the Model 7016 channel inputs and then measuring the amount of attenuation as the signal passes through the card.

Proceed as follows:

1. Set the network analyzer to sweep the 100MHz to 1.3GHz frequency range.
2. Normalize the analyzer reference channel to 0dB on the display.
3. Connect the network analyzer to the Model 7016 as shown in Figure 4-1. Be sure to use 50Ω cables and set-up for all insertion loss tests.
4. Install the Model 7016 in the Model 7001 or 7002 mainframe.

5. Close channel 1 on the Model 7016 card.
6. Verify that the insertion loss values are within the limits shown in Table 4-2.
7. Open the closed channel.
8. Repeat steps 3 through 7 for channels 2 through 8. For each channel:

   • Connect the analyzer signal to the input jack of the channel being tested.

   • Be sure the signal output cable is connected to the correct output jack.

   • Close the channel being tested.

   • Verify that the insertion loss values at the various frequencies are within the limits stated in Table 4-2.

Table 4-2
Insertion loss values

Frequency	Insertion loss
10MHz	<0.3dB
100MHz	<0.7dB
500MHz	<1.1dB
900MHz	<2dB
1.2GHz	<3dB
1.3GHz	<3dB

Table 4-1
Recommended verification equipment

Description	Manufacturer and Model	Specifications	Test
Network Analyzer Test set Cable set	Hewlett-Packard 8754A Hewlett-Packard 8753C Hewlett-Packard 11851	10MHz-1.3GHz	Insertion loss
Electrometer	Keithley 6517	100MΩ, ±0.151% 1GΩ, ±0.226%	Isolation
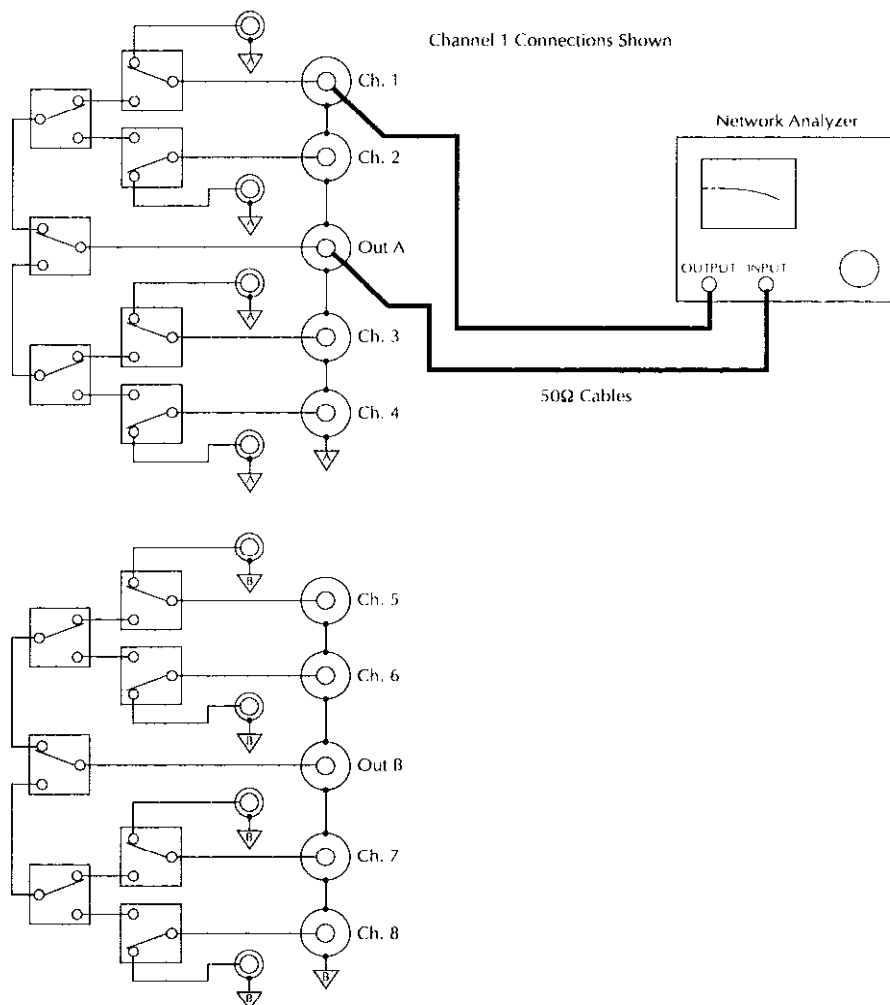
Figure 4-1
Connections for insertion loss tests

4.3.4 Isolation tests

These tests check the leakage resistance (isolation) between various Model 7016 terminals using the ohms function of a Model 6517 Electrometer.

CAUTION

The following tests use the Model 6517 voltage source to measure resistance. Do not apply more than 30V to the Model 7016 to avoid card damage.

Channel isolation tests

Perform the following steps to check channel isolation:

1. Connect the Model 6517 Electrometer to the center conductors of channels 1 and 2, as shown in Figure 4-2.
2. With the power off, install the Model 7016 card in the mainframe.
3. Turn on the mainframe and the Model 6517 power, and allow the electrometer to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.
4. Select the Model 6517 ohms function, choose the 200MΩ range, and make certain zero check is disabled.
5. Close channel 1 on the Model 7016.

6. Program the Model 6517 voltage source for 30V, and make sure the internal voltage source connection mode is selected.
7. Turn on the Model 6517 voltage source, and allow the reading to settle.
8. Verify that the Model 6517 resistance reading is >100MΩ.
9. Turn off the voltage source, and open channel 1.

10. Repeat the procedure for channels 2 through 4, measuring the resistance between the center conductor of each channel and the center conductors of all other channels of multiplexer A. For each test:

   • Connect the electrometer to the center conductors of the two channels being tested.

   • Close only one of the channels being tested.

11. Repeat the entire procedure to test channel isolation between all multiplexer B channels (channels 5-8).
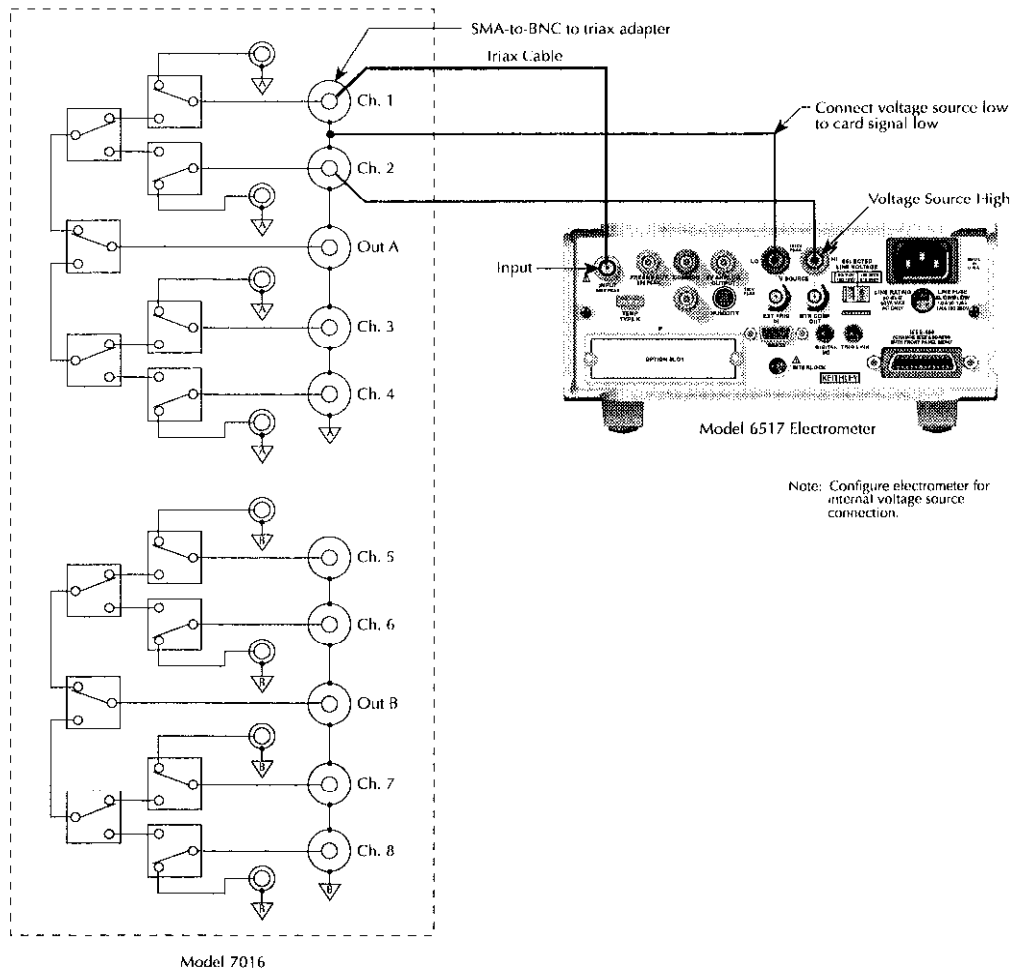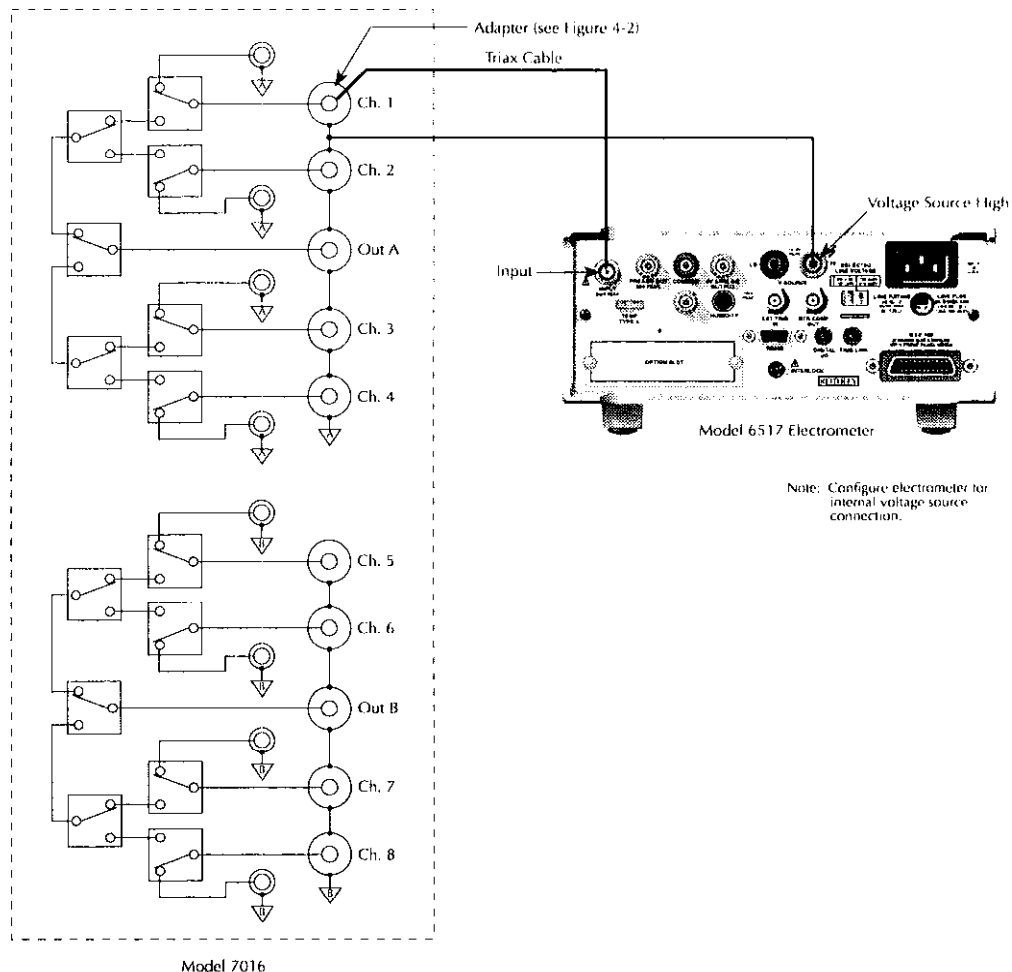

Figure 4-2
Connections for channel isolation tests

Center-to-shield isolation

Perform the following steps to check center-to-shield isolation:

1. Connect the Model 6517 Electrometer to the center conductor and shield of channel 1, as shown in Figure 4-3.
2. With the power off, install the Model 7016 card in the mainframe.
3. Turn on the mainframe and the Model 6517 power, and allow the electrometer to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.
4. Select the Model 6517 ohms function, choose the 2GΩ range, and make certain zero check is disabled.
5. Close channel 1 on the Model 7016.

6. Program the Model 6517 voltage source for 30V, and make sure the internal voltage source connection mode is selected.
7. Turn on the Model 6517 voltage source, and allow the reading to settle.
8. Verify that the Model 6517 resistance reading is >1GΩ.
9. Turn off the voltage source, and open channel 1.
10. Repeat the procedure for channels 2 through 8, measuring the resistance between the center conductor and shield of each channel. For each test:

    • Connect the electrometer to the center conductor and shield of the channel being tested.

   • Close only the channel being tested.

Figure 4-3
Connections for center-to-shield isolation tests

Multiplexer-to-multiplexer isolation

Perform the following steps to check multiplexer-to-multiplexer isolation:

1. Connect the Model 6517 Electrometer to the center conductors of channels 1 and 5, as shown in Figure 4-4.
2. With the power off, install the Model 7016 card in the mainframe.
3. Turn on the mainframe and the Model 6517 power, and allow the electrometer to warm up for at least one hour before making measurements. Make sure the voltage source is turned off.

4. Select the Model 6517 ohms function, choose the 2GΩ range, and make certain zero check is disabled.
5. Close channels 1 and 5 on the Model 7016.
6. Program the Model 6517 voltage source for 30V, and make sure the internal voltage source connection mode is selected.
7. Turn on the Model 6517 voltage source, and allow the reading to settle.
8. Verify that the Model 6517 resistance reading is >1GΩ.
9. Turn off the voltage source, and open channels 1 and 5.

Model 7016

Model 6517 Electrometer

Note: Configure electrometer for internal voltage source connection.
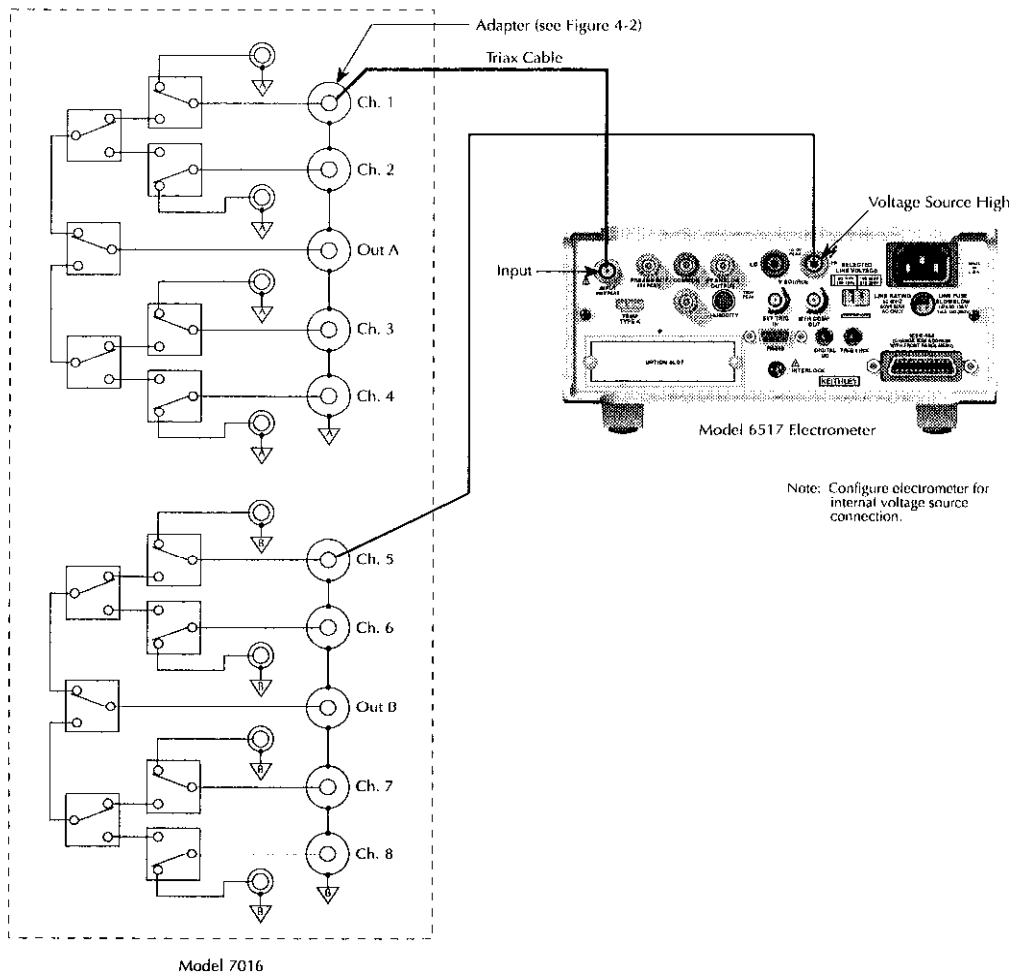
Figure 4-4
Connections for multiplexer-to-multiplexer isolation tests

4.3.5 Special handling of static-sensitive devices

CMOS and other high-impedance devices are subject to possible static discharge damage because of the high-impedance levels involved. When handling such devices, observe the precautions listed below.

NOTE

To prevent damage, assume that all parts are static-sensitive.

1. Such devices should be transported and handled only in containers specially designed to prevent or dissipate static build-up. Typically, these devices will be received in anti-static containers made of plastic or foam. Keep these parts in their original containers until ready for installation or use.

2. Remove the devices from their protective containers only at a properly grounded workstation. Also, ground yourself with an appropriate wrist strap while working with these devices.

3. Handle the devices only by the body; do not touch the pins or terminals.

4. Any printed circuit board into which the device is to be inserted must first be grounded to the bench or table.

5. Use only anti-static type de-soldering tools and grounded-tip soldering irons.

4.4 Principles of operation

The following paragraphs discuss the basic Model 7016 operating principles that can be used as an aid in troubleshooting the card. The schematic diagram of the card is located at the end of Section 5.

4.4.1 Block diagram

Figure 4-5 shows a simplified block diagram of the Model 7016. Key sections include the relay data control circuits, the relay driver IC, the relays, and the card configuration memory. These various elements are discussed in the following paragraphs.
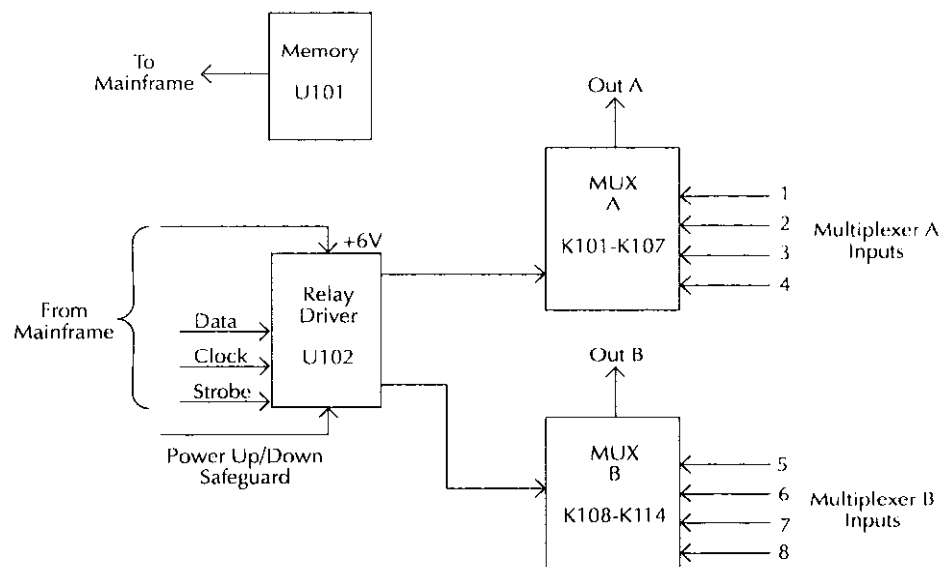
Figure 4-5
Block diagram

4.4.2   Relay control

Card relays are controlled by serial data transmitted from the host switching mainframe via the DATA line. Each control byte is shifted in serial fashion into latches located in the card relay driver IC (U102). The serial data is clocked in by the CLK (clock) line.

Once the relay control byte has been shifted into the card, the STR line is set high to latch the relay information into the Q outputs of the relay drivers, and the appropriate relays are energized (assuming the driver outputs are enabled, as discussed below). Note that a relay driver output goes low to energize the corresponding relay.

The output enable (OE) line of U102 is controlled by the power-up/power-down safeguard circuit located in the mainframe. This circuit assures that no card relays are inadvertently energized when the mainframe power is turned on or off.

4.4.3   Switching circuits

Signal switching is performed by relays K101 through K114. K104-K104 switch channels 1 through 4, while K108-K111 switch channels 5 through 8. K105-K107 provide additional switching to assure proper isolation for multiplexer 1, while K112-K114 provide a similar function for multiplexer 2.

4.4.4   Card configuration memory

Card configuration information is stored in U101. This information is serially read by the mainframe during power-up and allows the unit to determine the card model number and card relay configuration information.

4.5   Troubleshooting

4.5.1   Troubleshooting equipment

Table 4-3 summarizes recommended equipment for troubleshooting the Model 7016.

Table 4-3
Recommended troubleshooting equipment

Description	Manufacturer and Model	Application
Multimeter	Keithley	DCV checks
Oscilloscope	TEK 2243	View logic waveforms

4.5.2   Troubleshooting procedure

Table 4-4 summarizes multiplexer card troubleshooting steps. Refer to the schematic diagram and component layout drawing at the end of Section 5 for component locations.

CAUTION

Use care when removing relays from the PC board to avoid pulling traces away from the circuit board. Before attempting to remove a relay, use an appropriate de-soldering tool to clear each mounting hole completely free of solder. Each relay pin must be free to move in its mounting hole before removal. Also, make certain that no burrs are present on the ends of the relay pins.

Table 4-4
Troubleshooting procedure

Step	Item/component	Required condition	Comments
1	Digital ground P2001, pins 15 and 16		All voltages referenced to digital ground.
2	P2001, pin 1	+6VDC	Card 6V relay supply voltage.
3	P2001, pin 14	+5VDC	Card 5V logic supply voltage.
4	U102, pin 2	CLK pulses	During relay update sequence only.
5	U102, pin 3	DATA pulses	During relay update sequence only.
6	U102, pin 7	STR pulse	End of relay update sequence.
7	U102, pins 11-18	Low with relay energized, high with relay de-energized.	Relay driver outputs.

5

Replaceable Parts

5.1 Introduction

This section contains replacement parts information, schematic diagrams, and component layout drawings for the Model 7016.

5.2 Parts list

The parts list for the multiplexer card is included in tables integrated with the schematic diagram and component layout drawing. Parts are listed alphabetically in order of circuit designation.

5.3 Ordering information

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory (see the inside front cover for addresses). When ordering parts, be sure to include the following information:

- Card model number (7016)
- Card serial number
- Part description
- Circuit description, if applicable
- Keithley part number

5.4 Factory service

If the card is to be returned to Keithley Instruments for repair, perform the following:

- Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Complete the service form at the back of this manual and include it with the card.
- Carefully pack the card in the original packing carton.
- Write ATTENTION REPAIR DEPT and the RMA number on the shipping label.

NOTE

It is not necessary to return the switching mainframe with the card.

5.5 Component layout and schematic diagram

A component layout drawing and schematic diagram are included on the following pages integrated with the parts list.

Table 5-1
Model 7016, Parts List

Circuit Desig.	Description	Keithley Part Number
C101, 102	CAP, .1UF, 20%, 50V, CERAMIC	C-365-.1
C105, C106	CAP, 10UF, -20+100%, 25V, ALUM ELEC	C-314-10
CR101-106	DIODE, SILICON, 1N4148 (D0-35)	RF-28
J1001-1005, 1010-1014	CONNECTOR, SMA FEMALE	CS-839
J1006-1009, 1015-1018	CONN, SMB, MALE	CS-580
K101-114	RELAY, HI-FREQ, RK1E-5V	RL-147
P2001	CONNECTOR, 32-PIN, 2-ROWS	CS-775-1
U101	PROGRAM	7016-800**
U102	IC, 8-BIT SERIAL-IN LATCH DRIVER, 5841A	IC-536

** Order firmware revision of present ROM.

KEITHLEY

KEITHLEY INSTRUMENTS INC
CLEVELAND, OHIO 44139

NOTE: FOR MORE COMPONENT INFORMATION.
REFER TO THE 7016 PRODUCT STRUCTURE.

DIM ARE IN IN UNLESS OTHERWISE NOTED		DATE	2/9/94	SCALE 1:1			
DIM. TOL. UNLESS OTHERWISE SPECIFIED		DRN	MAH	APPR. P.S.			
XX=+.01	ANG.=+1						
XXX=+.005	FRAC.=+/.64	DO NOT SCALE THIS DRAWING					

TITLE COMPONENT LAYOUT

B NO. 7016-100

MODE   NEXT ASSEMBLY QTY.
USED ON

LTR.	ECA NO.	REVISION	ENG.	DATE
C	17170R	RELEASED		2/16/95

7016-100   NO.

Index

KEITHLEY

Service Form

Model No. _____ Serial No. _____ Date _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

❏ Intermittent   ❏ Analog output follows display   ❏ Particular range or function bad; specify

❏ IEEE failure   ❏ Obvious problem on power-up   ❏ Batteries and fuses are OK
❏ Front panel operational   ❏ All ranges or functions are bad   ❏ Checked all cables

Display or output (check one)

❏ Drifts   ❏ Unable to zero
❏ Unstable   ❏ Will not read applied input
❏ Overload

❏ Calibration only   ❏ Certificate of calibration required
❏ Data required
(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

What power line voltage is used? _____ Ambient temperature? _____°F

Relative humidity? _____ Other?_____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

Be sure to include your name and phone number on this service form.