

Model 7999-4  
Microwave Switch  
Instruction Manual

Contains Operating and Servicing Information

**KEITHLEY**

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# Model 7999-4 SPDT Microwave RS-232 Switch Instruction Manual

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## 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 7999-4-901-01).....	September 1999
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## 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.

The types of product users are:

**Responsible body** is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

**Operators** use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

**Maintenance personnel** perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

**Service personnel** are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

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.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

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 mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

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.

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The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.


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 panels, or switching 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 the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a 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 in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

# 7999-4 Microwave SPDT RS-232 Switch

**CONTACT CONFIGURATION:** Single Pole Double Throw.

**CONNECTOR TYPE:** 3-SMA type connectors (COMMON, NO, NC).

**MAXIMUM SIGNAL:** 120W 3GHz (VSWR 1.15 or less), CAT I.

**CONTACT RESISTANCE:** 0.1Ω max.

**CONTACT LIFE: Mechanical:**  $5 \times 10^6$  (at 180cpm).

**Electrical:**  $5 \times 10^6$  (3GHz, 50Ω, VSWR 1.2 at 20cpm).

**MAXIMUM COMMON MODE:** 42V peak, any terminal to earth.

**ACTUATION TIME:** 25ms.

**RELAY CHARACTERISTICS (50Ω):**

Frequency	To 1GHz	1- 4GHz	4- 8GHz	8- 12.4GHz	12.4- 18GHz
<b>VSWR (max)</b>	1.1	1.15	1.25	1.35	1.5
<b>Insertion Loss (dB max.)</b>	0.2	0.2	0.3	0.4	0.5
<b>Isolation (dB min.)</b>	85	80	70	65	60

## GENERAL

**INTERFACE:** RS-232 control (9600 baud, 8 data, 1 stop). Response terminator selectable (CR, LF, CRLF, LFCR).

**INDICATORS:** Power, relay position status.

**ENVIRONMENT: Operating:** 0° to 40°C, up to 35°C <80% RH.

**Storage:** -25° to 65°C.

**EMC:** Conforms with European Union Directive 89/336/EEC, FCC part 15 class B.

**SAFETY:** Conforms with European Union Directive 73/23/EEC.

**DIMENSIONS:** 109mm long × 112mm wide × 59mm deep (4.3" × 4.4" × 2.3").

**ACCESSORIES SUPPLIED:** AC/DC power adapter with line cord, user and service manual.

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# 1 General Information

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## Introduction

This section contains general information about the Model 7999-4 Microwave SPDT switch. The information is organized as follows:

- Feature overview
- Warranty information
- Manual addenda
- Safety symbols and terms
- Specifications
- Unpacking and inspection
- Connections

If you have any questions after reviewing this information, please contact your local Keithley representative or call one of our Applications Engineers at 1-800-348-3735 (U.S. and Canada only). Worldwide phone numbers are listed at the front of this manual.

## Feature overview

The Model 7999-4 is a single channel Microwave SPDT switch with the following features:

- SMA connectors
- RS-232 relay control
- +12V DC power connections
- Operating range from DC to 18GHZ

## Warranty information


Warranty information is located at the front of this instruction manual. Should your Model 7999-4 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the switch for repair, be sure to fill out and include the service form at the back of this manual to provide the repair facility with the necessary information.


## Manual addenda

Any improvements or changes concerning the switch or manual will be explained in an addendum included with the manual. Be sure to note these changes and incorporate them into the manual.

## Safety symbols and terms

The following symbols and terms may be found on the switch or used in this manual.

The  symbol indicates that the user should refer to the operating instructions located in the manual.

The  symbol shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

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 switch. Such damage may invalidate the warranty.

## Specifications

Full Model 7999-4 specifications are included at the front of this manual.

## Unpacking and inspection

### Inspection for damage

The Model 7999-4 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 switch from the bag, observe the precautions on handling discussed below.

### Handling precautions

- Always grasp the switch by the covers. Do not touch board surfaces or components.
- After removing the switch 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 switch is not installed and connected, keep the switch in its anti-static bag, and store it in the original packing carton.

## Shipment contents

The following items are included with every Model 7999-4 order:

- Model 7999-4 Microwave SPDT Switch
- PS-57A Power Supply Module (AC/DC converter 100-240VAC to 12VDC) / IEC AC inlet
- Model 7999-4 Instruction Manual (this manual)
- Additional accessories as ordered

## Instruction manual

If an additional Model 7999-4 Instruction Manual is required, order the manual package, Keithley part number 7999-4-901-00. The manual package includes an instruction manual and any pertinent addenda.

## Repacking for shipment

Should it become necessary to return the Model 7999-4 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Advise as to the warranty status of the switch.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.
- Fill out and include the service form located at the back of this manual.

## Connections

The following are available Model 7999-4 connections:

- Power receptacle: 3-pin phoenix jack for supplied power module
- RS-232 port: DB-9 connector
- Common, NC, and NO: 3-SMA (female) connectors

**NOTE** Refer to Section 2 for detailed connection information.

# 2 Connections

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## Introduction

This section contains information about overall switch configuration and connections and is organized as follows:

- Handling precautions
- Configuration
- Connections

**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.

## Handling precautions

To maintain high-impedance isolation, care should be taken when handling the switch to avoid contamination from such foreign materials as body oils. Such contamination can reduce isolation resistance. To avoid possible contamination:

- Always grasp the switch by the case
- Do not touch connector insulators
- Operate the card in a clean environment. If the card becomes contaminated, it should be thoroughly cleaned as explained in Section 4.

## Configuration

### Layout

Figure 2-1 shows the general layout of the Model 7999-4 which features:

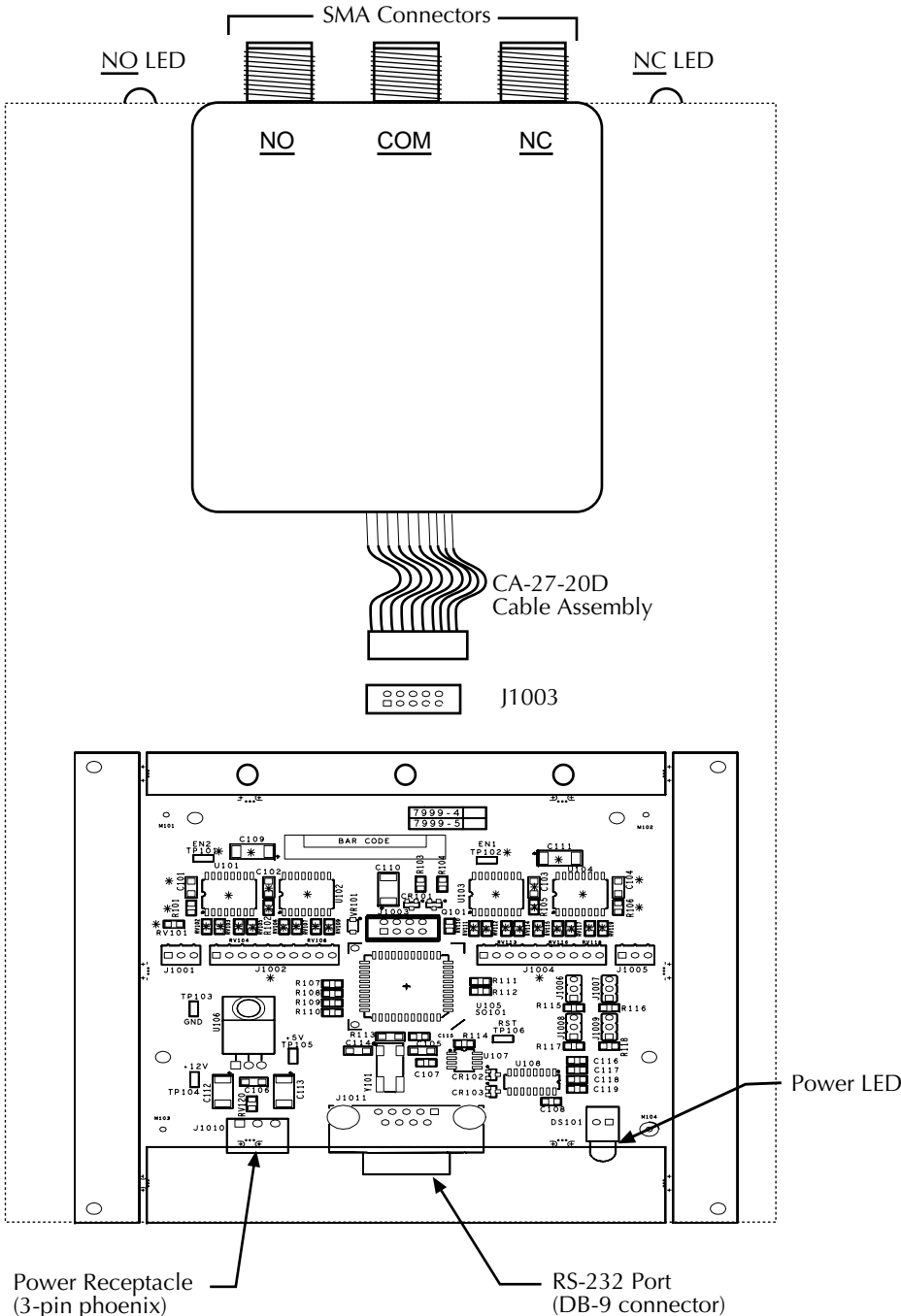
Connectors:

- Power receptacle: 3-pin phoenix jack for supplied power module
- RS-232 port: DB-9 connector
- Common, NC, and NO: 3-SMA (female) connectors

Indicators:

- Power LED
- NC LED (normally closed relay)
- NO LED (normally open relay)

Figure 2-1  
General layout

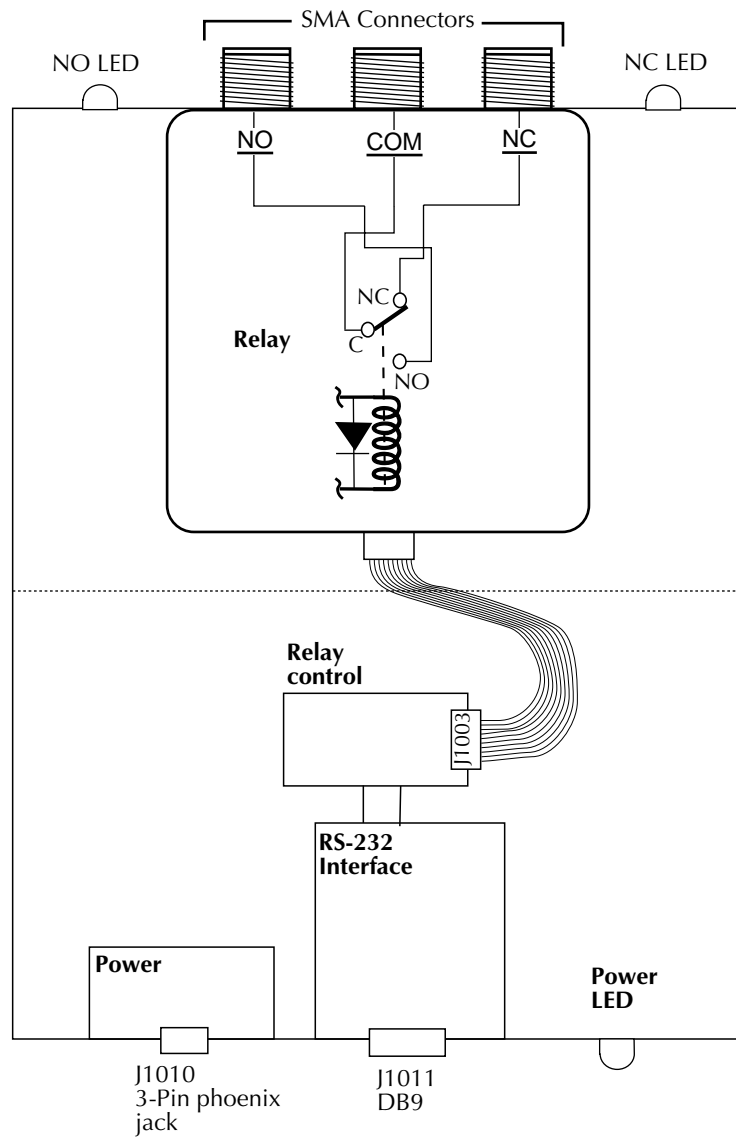


## Simplified schematic

Figure 2-2 shows a simplified schematic diagram of the Model 7999-4. The schematic is arranged into four sections:

- Power
- RS-232 interface
- Relay control
- Relay

**Figure 2-2**  
Simplified schematic



# Connections

## RS-232 Connection

The RS-232 serial port is connected to the serial port of a computer (controller) using a straight-through RS-232 cable terminated with DB-9 connectors. Do not use a null modem cable. The serial port uses the transmit (TXD), receive (RXD), and signal ground (GND) line of the RS-232 standard. Figure 2-3 shows the Model 7999-4 connector with Table 2-1 containing the pinouts for the connector.

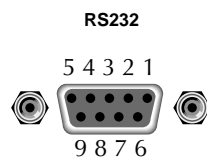
If your computer uses a DB-25 connector for the RS-232 interface, an additional cable or adapter (DB-25 to DB-9) is required.

**NOTE** *In the RS-232 interface, only pins 2, 3, and 5 are used. Pins 7 and 8 are tied together, but not connected to the circuit board. Pins 1, 4, and 6 are also tied together and not connected to the circuit board.*

**Table 2-1**  
RS-232 connector terminals

Pin Number	Description
1	Tied to pins 4 and 6
2	TXD, Transmit data
3	RXD, Receive data
4	Tied to pins 1 and 6
5	GND, Signal ground
6	Tied to pins 1 and 4
7	Tied to pin 8
8	Tied to pin 7
9	Not used

**Figure 2-3**  
RS-232 interface  
connector



## **SMA connectors**

The Model 7999-4 has three SMA connectors which represents the Common, NO (normally open), and NC (normally closed) connections of the relay.

## **Power connector**

Connect the supplied power adapter (Model PS-57A) to the power connector.

**WARNING** To prevent damage to the Model 7999-4, use only the Keithley Model PS-57A AC/DC power adapter. This is a universal input (100V - 240VAC, 50/60Hz), 12VDC output (3A or less) supply.

# 3 Operation

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## Introduction

This section contains operating information for the Model 7999-4. The information is organized as follows:

- Maximum signal considerations
- Toggle relay state switch
- Operation (RS-232)
- Switching considerations

## Maximum signal considerations

**WARNING** Maximum voltage between any conductor and ground is 42V.

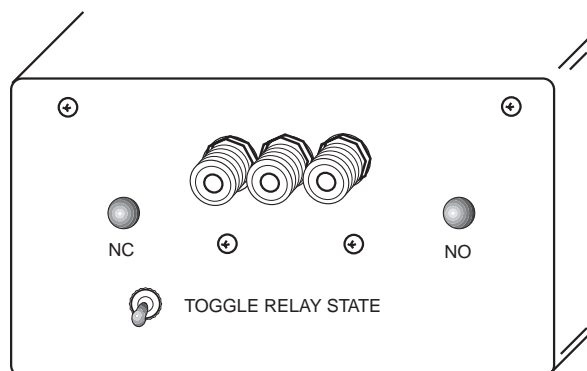
**CAUTION** To prevent damage to the Model 7999-4, do not exceed the following maximum signal level specifications of the switch:

- Maximum voltage: 30V DC, 42V peak
- Maximum current: 1A DC, switched

## Toggle relay state switch

Use this switch to manually toggle the relay, i.e., if the relay is closed, operating the switch opens the relay, if the relay is open, operating the switch closes the relay. After operating this spring loaded switch (pushing the switch left or right), the switch returns to the center (neutral) position while the relay stays in the toggled position. Refer to Figure 3-1.

**Figure 3-1**  
Toggle relay  
state switch



## Operation (RS-232)

### Sending and receiving data

The Model 7999-4 relay is RS-232 controlled. Before the relay can be controlled, connect an appropriate and properly configured controller to the DB-9 port. The Model 7999-4 serial interface (RS-232) transfers data using 8 data bits, no parity, and 1 stop bit (8-N-1). The interface also transfers data at 9600 baud. Make sure that the controller selected also uses these settings.

### Termination characters

The Model 7999-4 can be configured to terminate each program message transmitted to the controller with any of the following combinations of <CR> or <LF>:

- <CR> Carriage return (factory default setting)
- <CR+LF> Carriage return and line feed
- <LF> Line feed
- <LF+CR> Line feed and carriage return

To configure the termination character, change the jumpers for PA6 (J1006) and PA7 (J1008) located on the Model 7999-4 printed circuit board. Refer to Table 3-1 and Figure 3-2 for jumper details. Refer to the first three steps of disassembly information in Section 4 to access the circuit board.

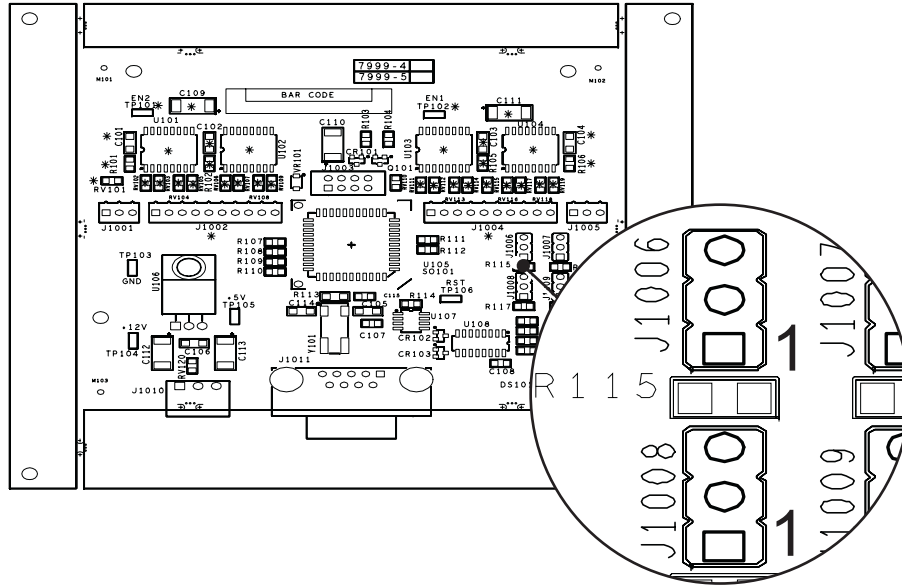
**Table 3-1**  
*Jumper positions—termination characters*

Terminator	J1006 pins	J1008 pins
<CR> <sup>1</sup>	1 and 2 <sup>1</sup>	1 and 2 <sup>1</sup>
<CR+LF>	2 and 3	1 and 2
<LF>	1 and 2	2 and 3
<LF+CR>	2 and 3	2 and 3

<sup>1</sup>Factory default setting



**Figure 3-2**  
Jumper location



## RS-232 Commands

Refer to Table 3-2 for a list of commands included in the command set.

**Table 3-2**  
*Command set*

Function	ASCII Command	Description
Open the relay	O or o	After the open command is sent, a 25msec delay occurs which allows the relay to settle. After the relay settles, an ASCII '1' is sent over the RS-232 indicating settling time has run out.
Close the relay	C or c	After the closed command is sent, a 25msec delay occurs which allows the relay to settle. After the relay settles, an ASCII '1' is sent over the RS-232 indicating settling time has run out.
Query relay state	S or s	Upon receiving this command, if the relay is closed an ASCII 1 is returned; if the relay is open, an ASCII 0 is returned.
Firmware information	I or i	Firmware information can be retrieved over the RS-232 using the 'I' command. After the command is sent, 'Keithley Instruments Inc., Model 7999-4, rev A01' (or similar due to firmware revision level) will be returned over the RS-232.

**NOTE** ASCII characters not included in the command set are ignored.

## Switching considerations

Signals switched by the Model 7999-4 may be subject to various effects that can seriously affect their integrity. The following paragraphs discuss these effects and ways to minimize them.

### Connector integrity

As is the case with any high-resistance device, the integrity of connectors can be damaged if they are not handled properly. If connector insulation becomes contaminated, the insulation resistance will be substantially reduced, affecting high-impedance measurement paths. Refer to Section 4 for cleaning information.

Oils and salts from the skin can contaminate connector insulators, reducing their resistance. Also, contaminants present in the air can be deposited on the insulator surface. To avoid these problems, never touch the connector insulating material. In addition, use the relay only in clean, dry environments to avoid contamination.

### Voltage standing wave ratio

The Voltage Standing Wave Ratio (VSWR) is a measurement of mismatch in a cable, waveguide, or antenna system. The measurement is shown as ratio to 1, e.g., a VSWR of 1.2 is actually the ratio of 1.2:1. Refer to the specifications located at the front of this manual for Model 7999-4 VSWR information (specifications are shown with a 50 $\Omega$  load).

### Path isolation

The path isolation is the equivalent impedance between any two test paths in a measurement system. Ideally, the path isolation should be infinite, but the actual resistance and distributed capacitance of cables and connectors results in less than infinite path isolation values for these devices.

Path isolation resistance forms a signal path that is in parallel with the equivalent resistance of the DUT. For low-to-medium device resistance values, path isolation resistance is seldom a consideration; however, it can seriously degrade measurement accuracy when testing high-impedance devices. The voltage measured across such a device, for example, can be substantially attenuated by the voltage divider action of the device source resistance and path isolation resistance. Also, leakage currents can be generated through these resistances by voltage sources in the system. Refer to the specifications located at the front of this manual for Model 7999-4 isolation information.

## Insertion loss

Insertion loss indicates signal lost while passing through the switch. This loss occurs in the various signal path components through the switch connectors, PC board traces, and relay. Refer to the specifications located at the front of this manual for Model 7999-4 insertion loss information.

## RFI/EMI

RFI (Radio Frequency Interference) and EMI (Electromagnetic Interference) are general terms used to describe electromagnetic interference over a wide range of frequencies across the spectrum. Such interference can be particularly troublesome at low signal levels, but it can also affect measurements at high levels if the problem is of sufficient severity.

EMI can be caused by steady-state sources such as radio or TV broadcast signals, or some types of electronic equipment (microprocessors, high speed digital circuits, etc.), or it can result from impulse sources, as in the case of arcing in high-voltage environments. In either case, the effect on the desired signal can be considerable if enough of the unwanted signal is present.

EMI can be minimized in several ways. The most obvious method is to keep the equipment and signal leads as far away from the RFI source as possible. Shielding the switching switch, signal leads, sources, and measuring instruments will often reduce RFI to an acceptable level. In extreme cases, a specially constructed screen room may be required to sufficiently attenuate the troublesome signal.

# 4 Service Information

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## Introduction

This section contains service information for the Model 7999-4. The information is organized as follows:

- Handling and cleaning precautions
- Performance verification
- Component replacement

**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.

## Handling and cleaning precautions

Because of the high-impedance areas on the Model 7999-4, care should be taken when handling or servicing the switch to prevent possible contamination. The following precautions should be observed when servicing the switch.

### Handling precautions

Observe the following precautions when handling the SPDT switch:

- Handle the switch only by the edges and cover.
- 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 switch, wear clean cotton gloves.
- Do not store or operate the switch in an environment where dust could settle on the circuit board.

### Card and connector cleaning

- Use dry nitrogen gas to clean any dust off the circuit board and components.
- Clean the contaminated area with methanol, then blow dry the entire board with dry nitrogen gas.
- If the connector insulators should become contaminated, either by inadvertent touching, or from air-borne deposits, they can be cleaned with a cotton swab dipped in clean methanol.
- Before use, allow items cleaned to dry for several hours in a 50°C low-humidity environment. Use dry nitrogen to decrease drying time.

## Performance verification

The following paragraphs discuss performance verification procedures for the Model 7999-4 including a channel resistance verification procedure.

**CAUTION** Contamination will degrade the performance of the switch. To avoid contamination, always grasp the switch by the cover; do not touch the connectors.

**NOTE** Failure of any performance verification test may indicate that the microwave switch is contaminated. See “Handling and cleaning precautions” earlier in this section for information on cleaning the switch.

### Environmental conditions

All verification measurements should be made at an ambient temperature between 18° and 28°C, and at a relative humidity of less than 70%.

### Recommended equipment

Table 4-1 summarizes the equipment necessary for performance verification (channel resistance tests).

**Table 4-1**  
Recommended verification equipment

Manufacturer/Model	Equipment Description	Specifications
Keithley 2010	Digital Multimeter	10Ω range, 60ppm
Keithley 1681	Test Lead Sets (2)	Banana plug/clips

### Channel resistance tests

Perform the following steps to verify that the relays contact is closing properly, the relay resistance is within specification, and that the relay opens properly.

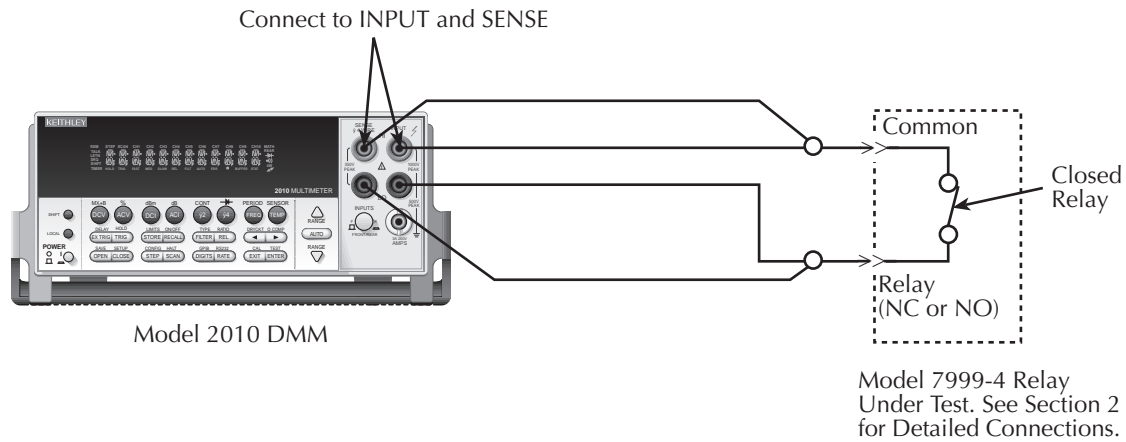
1. Turn on the Model 2010 DMM, and allow it to warm up for one hour before making measurements.
2. Set the Model 2010 to the 10Ω range, and connect the four test leads to the INPUT and SENSE Ω 4 WIRE jacks.
3. Short the free ends of the four test leads together, and enable REL on the Model 2010 to null out residual resistance. Leave REL enabled for the entire test.

4. Connect the Model 2010 INPUT and SENSE  $\Omega$  4 WIRE jacks to the NC relay contact and common, as shown in Figure 4-1.

**NOTE** Use 4-wire connections.

5. Close the relay.
6. Note the resistance reading on the Model 2010, and verify that it is  $<0.1\Omega$ .
7. Open the relay.
8. Note the resistance reading on the Model 2010, and verify that it indicates an open circuit.
9. Repeat the measurement for the NO relay (repeat steps 4 through 8 but with the DMM connected to the NO relay contact and common).

**Figure 4-1**  
Channel resistance  
test connections





# Replacing components

## Replacement parts

Replacement parts can be obtained directly from Keithley Instruments, Inc. See the parts list in Section 5 for part numbers.

## Replacement precautions

**CAUTION** Observe the following precautions when replacing components:

- **To avoid contamination, which could degrade switch performance, always handle the switch only by the covers and side edges. Do not touch the connector, board surfaces, or components on the switch.**
- **Use care when removing components 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.**

## Soldering considerations

When using 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.

## Disassembly

Perform the following steps to disassemble the Model 7999-4 to gain access to parts on the circuit board:

1. Remove the six screws that hold the case together and the two hex-nuts on the DB9 connector.
2. Separate the two halves of the case.
3. Unplug the connector from the relay.
4. Remove the screws that secure the PC board to the case, then remove the board.

# 5

## Replaceable Parts

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## Introduction

This section contains replacement parts information and component layout for the Model 7999-4.

## Parts list

Parts lists for the Model 7999-4 are contained in Table 5-1 and Table 5-2.

## Ordering information

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

- Switch model number (Model 7999-4)
- Serial number
- Part description
- Component designation (if applicable)
- Keithley part number

## Factory service

If the switch 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 instrument.
- Carefully pack the instrument in the original packing carton.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

## Component layout

The following component layout drawing is provided on the following page:

- Component layout drawing: 7999-4-100

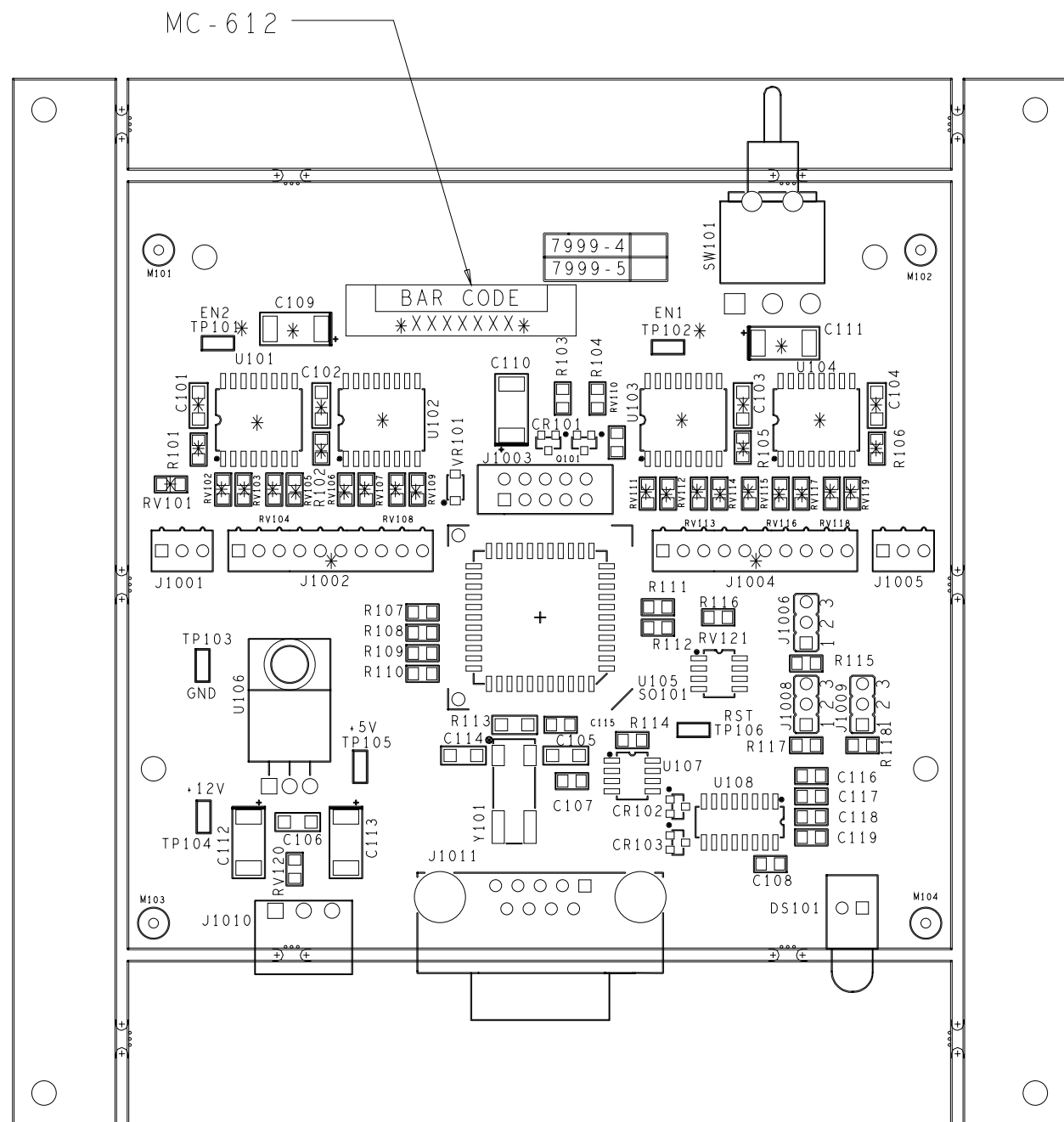
**Table 5-1**  
*Parts list—electronic components*

Circuit designation	Description	Keithley part no.
C105, C114	CAP, 33PF, 10%, 100V, CERAMIC	C-451-33P
C106	CAP, 0.1UF, 20%, 50V, CERAMIC	C-418-.1
C107, C108, C115–C119	CAP, 0.1UF, 10%, 25V, CERAMIC	C-495-.1
C110, C112, C113	CAP, 10UF, 20%, 25V, TANTALUM	C-440-10
CR101–CR103	DIODE, DUAL SWITCHING	RF-82
DS101	PILOT LIGHT, GREEN, LED	PL-78
J1001, J1005	LATCHING HEADER, FRICTON, SGL ROW	CS-724-3
J1003 (cable)	CABLE ASSEMBLY	CA-27-20D
J1006–J1009	CONN, BERG	CS-339
J1010	CONN, HORIZ, RECEPTACLE 3-PIN	CS-943-3
J1011	CONN, RT ANGLE, MALE, 9-PIN	CS-761-9
Q101	TRANS, NPN SILICON	TG-389
R103, R107–R110, R115–R118	RES, 10K, 1%, 100mW THICKFILM	R-418-10K
R104	RES, 4.02K, 1%, 100mW THICKFILM	R-418-4.02K
R111, R112, R114	RES, 4.75K, 1%, 100mW THICKFILM	R-418-4.75K
R113	RES, 10M, 5%, 125mW METAL FILM	R-375-10M
RV110	TRANSIENT VOLTAGE SUPPRESSOR	VR-12
RV120	TRANSIENT VOLTAGE SUPPRESSOR	VR-11
U107	IC, UNDERVOLTAGE SENSE CIRCUIT	IC-1067
U108	IC, RS-232 LINE DRIVER/RECEIVER	IC-1129
U105	IC, 8-BIT MICRO PROCESSOR	7999-4-800A01
U106	IC, +5V REGULATOR, 500mA	IC-93
VR101	DIODE, ZENER, 6.2V	DZ-97
Y101	CRYSTAL, 4MHZ	CR-36-4M

**Table 5-2**  
*Parts list—mechanical parts*

Description	Keithley part no.
Bracket (relay)	7999-4-304A
Cover (bottom)	7999-4-302A
Cover (top)	7999-4-301A
Female screw-lock	CS-725
Lock-nut	4-40KEPNUT
Phillips Pan Head Screw	4-40X1/4PPH
Phillips Pan Head Screw SEMS (black)	4-40X3/8PPHSEMBLK
Phillips Pan Head Screw SEMS (relay attaching hardware)	2-56x5/8PPHSEM

LTR.	ECA NO.	REVISION	ENG.	DATE
A	N/A	PRELIMINARY	MAH	7/8/99
B	23501	RELEASED	MAH	9/3/99
B1	24102	MC-612 WAS MC-285	CAD	2/11/00



7999-4-102

\*DO NOT POPULATE\*

PTH ; J1002, J1004

SMT ; C101-C104, C109, C111  
 TP101, TP102  
 R101, R102, R105, R106  
 RV101-RV109, RV111-RV119  
 U101-U104

REFER TO THE 7999-4-102 PRODUCT STRUCTURE FOR FURTHER COMPONENT INFORMATION.

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

<p>KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139</p>	DIM ARE IN IN. UNLESS OTHERWISE NOTED	DATE 7/8/99	SCALE 2:1	TITLE
	DIM. TOL. UNLESS OTHERWISE SPECIFIED	DRN MAH	APPR. DL	COMPONENT LAYOUT
	XX: .01 XXX: .005	ANG: .1 FRAC: .1/64	DO NOT SCALE THIS DRAWING	C No.

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## 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

Overload

Will not read applied input

Calibration only

Certificate of calibration required

Data required

(attach any additional sheets as necessary)

Show a block diagram of your measurement 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.



**KEITHLEY**

**Keithley Instruments, Inc.**

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