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## Remote Pulse Module Instructions

### Overview

The Keithley Instruments Model 4225-RPM Remote Preamplifier/Switch Module (RPM) is a remote amplifier and automatic switch. It is a multiplexer switch that automatically switches between precision dc source-measure units (SMUs), C-V, and the ultra-fast pulsed I-V instruments.

The RPM also extends the low current measurement capability of the 4225-PMU Ultra-Fast Pulsed I-V Instrument Module. This is especially important for devices like diodes or transistors that have I-V curves that extend over several decades of current. The autorange feature of the 4225-RPM enables automatic range selection while a pulsed I-V sweep is in progress. This feature provides optimal current measurement while the device signal transitions through different current levels. The RPM adds the following current ranges to the 4225-PMU: 100 nA, 1  $\mu$ A, 10  $\mu$ A, 100  $\mu$ A, 1 mA, and 10 mA.

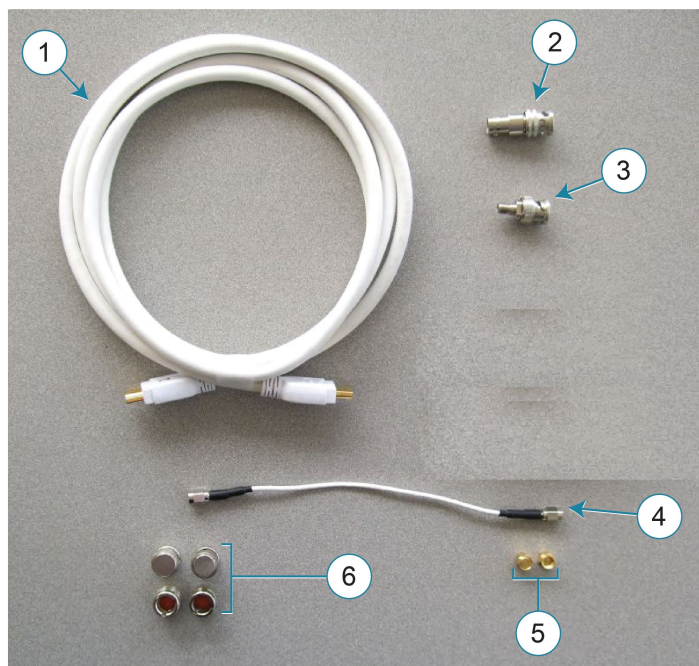
**Figure 1: 4225-RPM**



## Included accessories

The following cables, adapters, and accessories are included in the remote pulse module kit.

**Figure 2: 4225-RPM included accessories**



Item	Description	Keithley part number	Quantity
1	RPM interconnect cable, 2.4 m (8 ft)	CA-547-2.4	1
2	Triaxial to BNC adapter (guard removed)	CS-712	1
3	BNC-SMA female adapter	CS-1247	1
4	SMA to SMA cable, 20 cm (8 in.)	CA-452	1
5	Protective cap	CAP-47	2
6	Triaxial caps (for shielding, not shorting)	CA-31	4
Not shown	Support bracket	4200-322	1
Not shown	Captive panel screw (for support bracket)	FA-243-2	1
Not shown	Allen socket head capscrew, #4-40 x 5/16"	4-40x5/16SOHBLK	1
Not shown	Hex wrench, 3/32 in.	TL-32	1

## Available cable kits

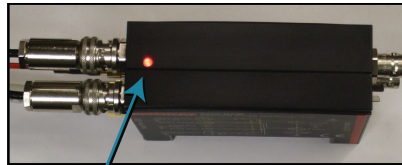
Model 4210-MMPC High Performance Triaxial Cable Kits (ordered separately) simplify RPM connections to a probe, simplifying switching between dc I-V, C-V, and pulsed I-V testing configurations. These optional kits are customized for specific probes. One kit is required for each pin of the device under test (DUT).

For additional information, refer to the 4200A-SCS Parameter Analyzer Datasheet, available from [tek.com/keithley](https://www.tek.com/keithley).

## Indicators

When the RPM is operational in a 4200A-SCS system, an LED on top of the RPM illuminates. The color of the LED indicates which instrument is connected to the DUT during a test. Use the color codes in the following figure to determine which instrument is connected. Note that the instrument indicator does not show that a test is running or that the output of an instrument is active. To determine if a test is running, check the status in Clarius.

**Figure 3: Instrument indicator**



Red = CVU (shown)

Blue = SMU

Green = PMU

## Switching and connections

The 4225-RPM allows for automatic switching between dc I-V, C-V, and pulsed I-V measurements when executed in ITM tests. The following topics describe typical connections for these measurements.

When properly installed, you can perform different electrical measurements on the device without having to disconnect and reconnect cabling for each test. Optional multi-measurement performance cable kits (Model 4210-MMPC) are available to connect the 4200A-SCS to a probe manipulator. In addition to eliminating the need for recabling, these kits help maximize signal fidelity by eliminating the measurement errors that often result from cabling errors.

## Connecting the RPM to the PMU

### CAUTION

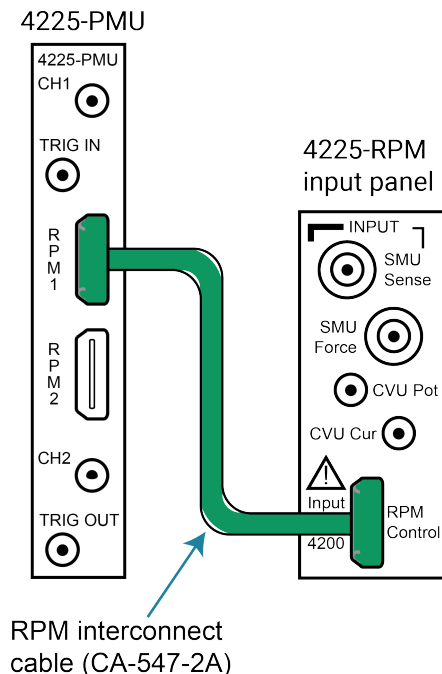
Turn off the system and disconnect the power cord before connecting or disconnecting the RPM to or from the PMU. Failure to do so may result in RPM or PMU damage, possibly voiding the warranty.

### NOTE

The RPM is matched to a PMU card and channel. Make sure to connect the RPM only to that PMU card and channel. Labels on top of the RPM indicate the specific connection channel and PMU. For example, "PMU1-2" indicates PMU1, channel 2.

With system power off, use the supplied RPM cable to connect a 4225-RPM to the matching RPM channel of the 4225-PMU, as shown in the following figure.

**Figure 4: 4225-PMU connection to an RPM**



## CAUTION

With an RPM installed, never make connections directly to any of the SMA connectors (CH1 and CH2) on the PMU. This may result in damage to the PMU or DUT. It may also produce corrupt data.

## NOTE

After connecting or removing an RPM, always perform the procedure “Update the RPM configuration” in *Model 4200A-SCS Setup and Maintenance* to ensure that KCon accurately represents the present 4200A-SCS hardware configuration.

## Mounting the RPM

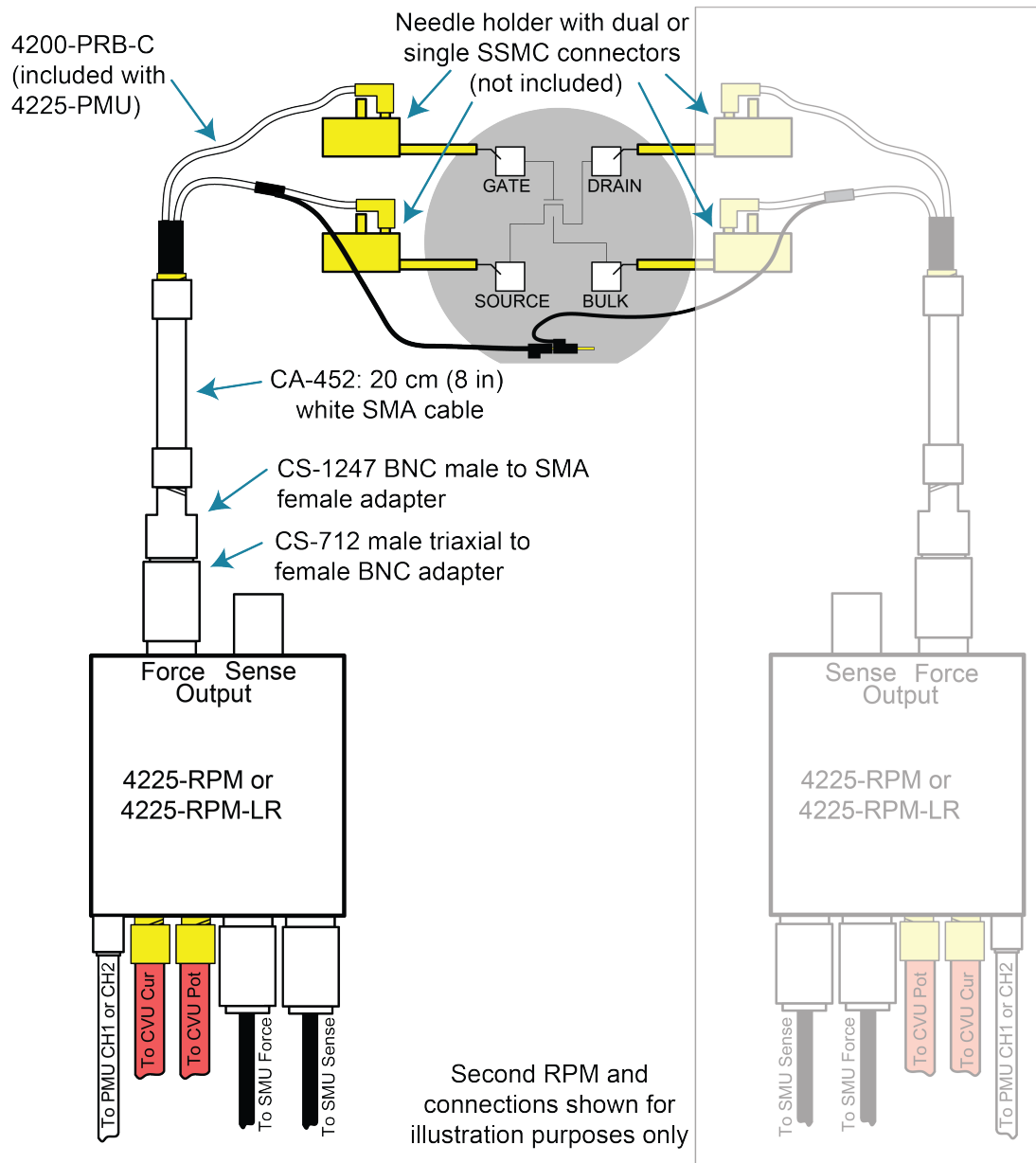
### CAUTION

When mounting the 4225-RPM, make sure that there is a minimum of 5 cm (2 in.) of space between multiple RPM base assemblies. Spacing multiple 4225-RPM or 4200-PA instruments closer than 5 cm (2 in.) from the 4200-MAG-BASE can cause the internal relays to malfunction.

## Connections to a 4-terminal device

The following illustrates the connection to a 4-terminal device using the cabling and adapters that are included with either RPM or the 4225-PMU.

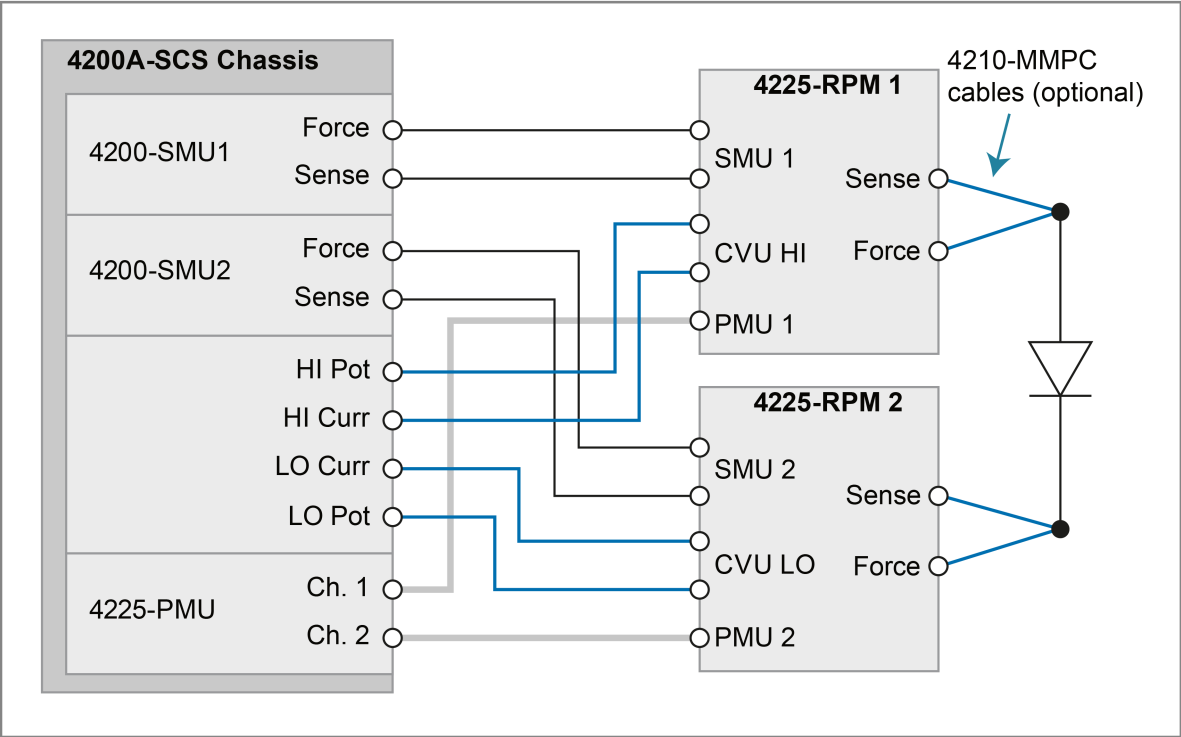
**Figure 5: RPM output connection to 4-terminal device**



## Typical 2-terminal connections

The following figure illustrates the connections to 2-terminal devices using the optional MMPC cabling. This figure shows two RPMs and two 4210-MMPC cable kits.

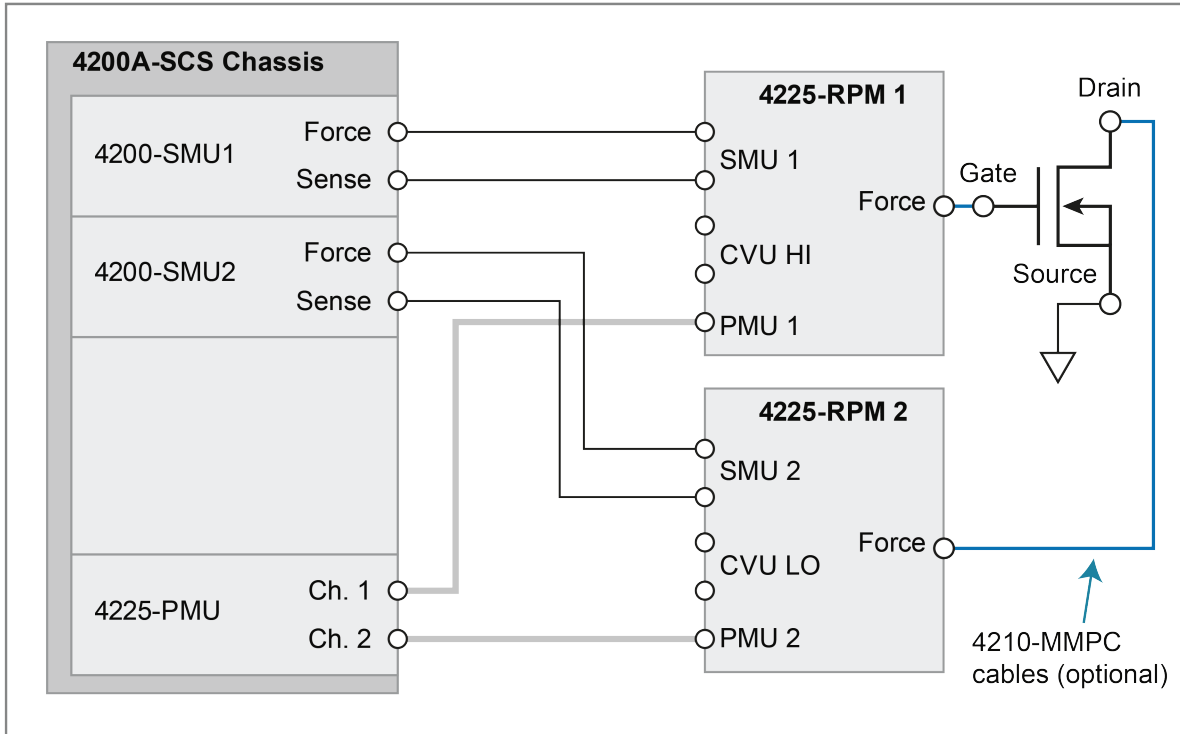
Figure 6: Typical diode connections



## Typical 4-terminal device connections

The following figure shows RPM connections to a 4-terminal device using three optional MMPC cable kits.

**Figure 7: Typical MOSFET connection**



## Load-line effect

The load-line effect causes voltage across the DUT to be lower than the programmed source voltage. The output resistance of a pulsing instrument causes this effect. This resistance causes a reduction in output voltage at the test device when current flows. By design, pulse instruments such as the 4225-PMU typically have 50  $\Omega$  of resistance when placed in series with the output. The resistance causes a voltage drop proportional to the current flow and is called the load-line effect.

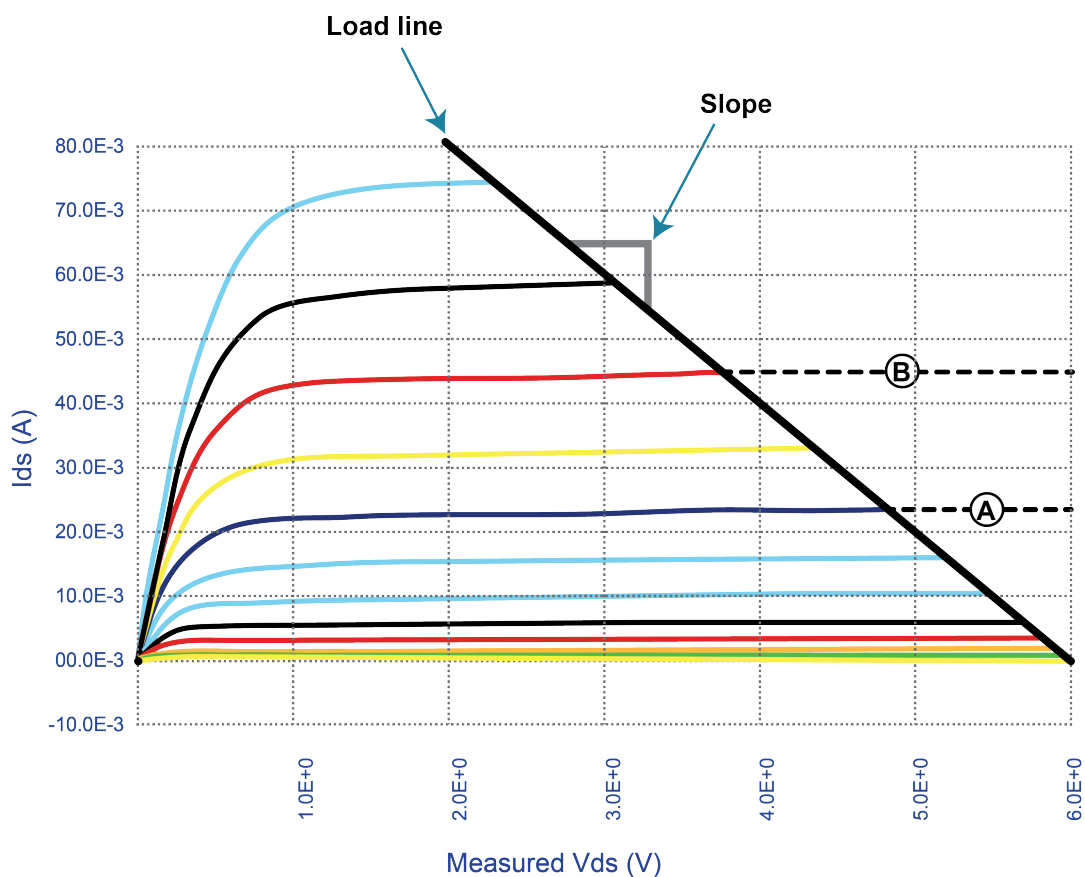
The following figure shows the result of the load-line effect when measuring standard transistor  $V_{DS}$ - $I_{DS}$  curves with the 4225-PMU on its 200 mA range. Even though the user specified a source voltage of 6 V with a current of about 25 mA (the blue curve at around  $25E-3$ ,  $I_{DS}$ ), about 4.8 V is applied to the DUT, while about 1.2 V (marked A) is dropped inside the 4225-PMU and is not applied to the DUT. The difference between the actual voltage sourced at the load line and the sourced voltage is caused by the load-line effect. The amount shown at A is more than 1 V of loss. Increasing the amperage of the curve increases this effect. The amount shown at B is more than 2 V of loss.

The load line is defined by  $V_{SRC}$  and the resistance of the pulse instrument. The output resistance of the 4225-PMU entirely determines its slope. The 4225-PMU programmed source voltage determines its horizontal position. Larger voltages shift the line to the right. Smaller voltages shift it to the left. For a given programmed source voltage, the actual DUT voltage cannot go beyond this line.

The slope is defined by the equation:

$$\text{slope} = -1/R_{SRC}$$

**Figure 8: VDS-IDS curves for a MOSFET showing the load-line effect at high currents**



The 4225-RPM has resistance in series with its output (typically between  $20 \, \Omega$  and  $50 \, \Omega$ ). It also exhibits the load-line effect.



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 nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

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 properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. 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, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

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 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators 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 V, no conductive part of the circuit may be exposed.

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, ensure that 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.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

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.


For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.


Do not exceed the maximum signal levels of the instruments and accessories. Maximum signal levels are defined in the specifications and operating information and shown on the instrument panels, test fixture panels, and switching cards.


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

Chassis connections must only be used as shield connections for measuring circuits, NOT as protective earth (safety 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 protective earth (safety ground) using the wire recommended in the user documentation.

The  symbol on an instrument means caution, risk of hazard. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means warning, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.


The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains hazards that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

The **CAUTION** heading with the  symbol in the user documentation explains hazards that could result in moderate or minor injury or damage the instrument. Always read the associated information very carefully before performing the indicated procedure. Damage to the instrument 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. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. 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 to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F); and pollution degree 1 or 2.

To clean an instrument, use a cloth dampened with deionized water 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., a 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.

Safety precaution revision as of June 2018.