KEITHLEY

Model 248 High Voltage Supply

Instruction Manual

A GREATER MEASURE OF CONFIDENCE

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 248 High Voltage Supply
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.

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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.

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 the 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.

248 High Voltage Supply

VOLTAGE RANGE: 0 to ±5000V DC[1]

Output Voltage	Maximum Output Current	Conditions
0 to ± 5000 V DC	5.000 mA DC	NO FILTER
0 to ± 3000 V DC	5.000 mA DC	FILTER 1
0 to ± 5000 V DC	3.000 mA DC	FILTER 2

VOLTAGE SET ACCURACY: ±(0.01% of setting + 0.05% of range).

VOLTAGE DISPLAY ACCURACY: Voltage Set Accuracy ±1V, typical (±2V, max.).

VOLTAGE RESOLUTION: 1V (set and display).

VOLTAGE RESETTABILITY: 1V.

VOLTAGE LIMIT RANGE: 0 to 100% of full scale.

VOLTAGE REGULATION[2]**:**
- **Line:** 0.001% for ±10% line voltage change.
- **Load:** 0.005% for 100% load change, typical.

OUTPUT RIPPLE (10Hz–100kHz)[3]**:**

0.002% of full scale, Vrms, max.	NO FILTER
1.0mV rms @ 1kV	FILTER 1 or FILTER 2
2.0mV rms @ 3kV	FILTER 1 or FILTER 2
3.0mV rms @ 5kV	FILTER 2

CURRENT VOLTAGE	CURRENT LIMIT AND TRIP RANGE	FILTER
0 V to 1.5 kV	0.4 mA to 5.25 mA	NO FILTER or FILTER 1
	0.4 mA to 3.25 mA	FILTER 2
1.5 kV to 5.0 kV	0.5 mA to 5.25 mA	NO FILTER or FILTER 1
	0.5 mA to 3.25 mA	FILTER 2

CURRENT LIMIT ACCURACY: 0.01% + 2.5µA.

CURRENT RESOLUTION: 1µA.

CURRENT DISPLAY ACCURACY: Current Set Accuracy ±1µA, typ. (±2µA, max.).

STABILITY: ±0.02% per hour typical for ambient temperature within 2°C.

TEMPERATURE DRIFT: 50ppm/°C, 0° to 50°C, typical.

PROTECTION: Arc and short circuit protected; programmable voltage and current limits and current trip.

SETTLING TIME:
- **From 0 to Programmed Voltage:** To within 99.9% of final value within 3s.
- **Discharge Time from Programmed Voltage to Within 50V of Zero:** Within 6s for no load (faster with load, slower with filters on).

MONITOR OUTPUTS:
- **Output Scale:** 0 to +10V for 0 to full range output regardless of polarity.
- **Current Rating:** 10mA maximum.
- **Output Impedance:** <1Ω.
- **Accuracy:** ±0.2% of full scale.
- **Update Rate:** 8Hz.

EXTERNAL VOLTAGE SET:
- **Input Scale:** 0 to +10V for 0 to full range output regardless of polarity.
- **Input Impedance:** 1MΩ.
- **Accuracy:** ±0.2% of full scale.
- **Update Rate:** 16Hz.
- **Output Slew Rate:** <0.3s for 0 to full range under full load.

NOTES:

[1] Polarity of output is set with a rear panel switch. The unit must be powered off and the output fully discharged before changing polarity.

[2] Regulation specifications apply for greater than 25V DC (with full load) or 50V DC (with no load). Below these values, the unit may not regulate correctly.

[3] Peak to peak values are within five times the rms value.

GENERAL

DIMENSIONS: 89mm high × 206mm wide × 406mm deep (3.5 in × 8.1 in × 16 in).

WEIGHT: 3.7 kg (8 lbs).

INPUT POWER: 55 watts; 100, 120, 220, 240V AC ±10%, 50 or 60Hz.

OUTPUT HIGH VOLTAGE CONNECTOR: SHV male (Kings Type 1704-1 or equivalent), on rear panel.

REMOTE INTERFACE: GPIB (IEEE-488.1).

WARRANTY: One year parts and labor on materials and workmanship.

WARM-UP TIME: 1 hour.

OPERATING ENVIRONMENT: 0°C to 50°C.

ACCESSORIES AVAILABLE

248-MHV	High Voltage Female-to-Male Cable, 3m (10 ft)
248-SHV	High Voltage Female-to-Female Cable, 3m (10 ft)
248-RMK-1	Single Fixed Rack Mount Kit: Mounts a single Model 248 in a standard 19-inch rack.
248-RMK-2	Dual Fixed Rack Mount Kit: Mounts two Model 248s side-by-side in a standard 19-inch rack.

Specifications are subject to change without notice.

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1

General Information

1.1 Introduction

The Model 248 High Voltage Supply, designed for use in the laboratory or for test applications, features reversible polarity, excellent regulation, and low output voltage ripple. The digital displays provide accurate readings of voltage and current, and digital entry of current and voltage values allow easy, precise setting of output values. Output voltage can be set from the front panel, via a remote analog voltage, or over the standard IEEE-488 interface. Voltage and current signals are also available for remote monitoring.

1.2 Features

Key Model 248 features include:

- High voltage operation — The unit can source voltages up to a maximum of 5kV.
- 25W power capability — The Model 248 can source currents up to 5mA at 5kV.
- Ease of use — Digital displays and data input simplify voltage and current voltage setting.
- Programmable voltage limit — Voltage limit can be preset to assure safe operation.
- Programmable current limits — Current limit and trip point can be preset to prevent possible equipment damage.
- Output filter — Reduces output ripple and noise.
- Monitor outputs — Provide 0 -10V signals that can be used to monitor the output voltage and current.
- External voltage control — Allows the voltage source output value to be controlled with a 0 -10V input signal.
- Standard IEEE-488 interface — Allows the instrument to be controlled over the IEEE-488 bus.

1.3 Warranty information

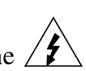
Warranty information is located on the inside front cover of this instruction manual. Should your Model 248 require warranty service, contact your Keithley representative or an authorized repair facility in your area for further information. When returning the unit for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.

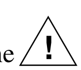
1.4 Manual addenda

Any improvements or changes concerning the unit or manual will be explained on an addendum. Addenda are provided in a page replacement format. Simply replace the obsolete pages with the new pages where indicated.

1.5 Safety symbols and terms

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

The  symbol indicates that 1000V or more may be present on the terminals.

The  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 unit. Such damage may invalidate the warranty.

1.6 Specifications

Detailed Model 248 specifications are located at the front of this manual.

1.7 Unpacking and inspection

1.7.1 Inspection for damage

Upon receiving the Model 248, carefully unpack the unit, and inspect for any obvious signs of physical damage that might have occurred during shipment. Notify the shipping agent of any damage immediately.

1.7.2 Shipment contents

The following items are included with every Model 248 order:

- Model 248 High Voltage Supply
- Model 248 Instruction Manual
- Additional accessories as ordered

1.7.3 Instruction manual

If an additional Model 248 Instruction Manual is required, order the manual package, Keithley part number 248-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.8 Optional accessories

The following optional accessories are available for use with the Model 248.

1.8.1 Connecting cables

Model 248-SHV: SHV-to-SHV high voltage cable, 10 feet in length.

Model 248-MHV: SHV-to-MHV high voltage cable, 10 feet in length.

1.8.2 Rack mount kits

Model 248-RMK-1: Mounts a single Model 248 in a standard 19-inch rack.

Model 248-RMK-2: Mounts two Model 248s side-by-side in a standard 19-inch rack.

2

Operation

2.1 Introduction

This section contains detailed information on operating the Model 248 from the front panel. For IEEE-488 bus programming information, refer to Section 3.

2.2 Safety precautions

Be sure to observe the safety precautions below before operating the Model 248.

WARNING

The Model 248 is capable of sourcing hazardous high voltages that can cause personal injury or death due to electric shock. This unit should be used only by qualified personnel who recognize the dangers of high voltages.

Make certain that the source is turned off and that high voltage is completely discharged before removing the high voltage cable. High voltage cables can store charge if they are disconnected from the supply while the high voltage is on. The charge on the cable can cause injury or damage even after the cable is disconnected from the unit.

CAUTION

Do not change the high voltage polarity unless the power is off. Doing so may damage the unit.

2.3 Preparation for use

2.3.1 Line voltage selection

The Model 248 operates from a 100, 120, 220, or 240V nominal AC power source with a line frequency of 50 or 60 Hz. Before connecting the power cord to a power source, verify that the line voltage selector card, located in the rear panel fuse holder, is set for the correct AC line voltage.

CAUTION

This instrument may be damaged if operated with the line voltage selector set for the wrong AC line voltage, or if the wrong fuse is installed.

Conversion to other AC input voltages requires a change in the fuse holder voltage card position and fuse value.

WARNING

Disconnect the line cord before changing the line voltage setting or replacing the fuse.

Disconnect the power cord, open the fuse holder cover door, and rotate the fuse-pull lever to remove the fuse. Remove the small printed circuit board. Select the operating voltage by orienting the printed circuit board to the desired position. Press the circuit board firmly into its slot so that the desired voltage is visible. Rotate the fuse-pull lever back into its normal position, and insert the correct fuse into the fuse holder. See paragraph 2.3.2 for correct line fuse information.

2.3.2 Line fuse

Verify that the correct line fuse is installed before connecting the line cord as follows:

Line voltage	Fuse type	Keithley Part No.
100V/120V	1A, 250V, 3AG, Slo Blo	FU-10
220V/240V	1/2A, 250V, 3AG, Slo Blo	FU-4

2.3.3 Line cord

The Model 248 uses a detachable, three-wire power cord for connection to the power source and to a safety earth ground through a grounded AC outlet.

WARNING

The exposed metal parts of the instrument are connected to the outlet ground through the line cord to provide protection against electrical shock. Always use an AC outlet that has a properly connected safety earth ground.

2.3.4 Connection to other instruments

The rear panel SET/MON and I/MON BNC jack shields are connected to chassis ground and the AC power source ground via the power cord. Do not apply any voltage to the shields. The HIGH VOLTAGE SHV connector is also connected to chassis ground and cannot be floated above ground.

WARNING

This unit contains hazardous voltages. Be absolutely certain that the high voltage is completely discharged before removing or connecting the high voltage cable. High voltage cables can store charge if they are disconnected from the supply while high voltage is turned on, and can cause personal injury or death if not handled properly. Use only connecting cables with a rated working voltage of 5kV or higher.

Do not connect the HIGH VOLTAGE output to exposed circuitry. Any load connected to the HIGH VOLTAGE output should be enclosed in a metal shield that is connected to safety earth ground using #18AWG or larger wire.

2.4 Front panel summary

Figure 2-1 shows the front panel of the Model 248. The various controls are explained in the following paragraphs.

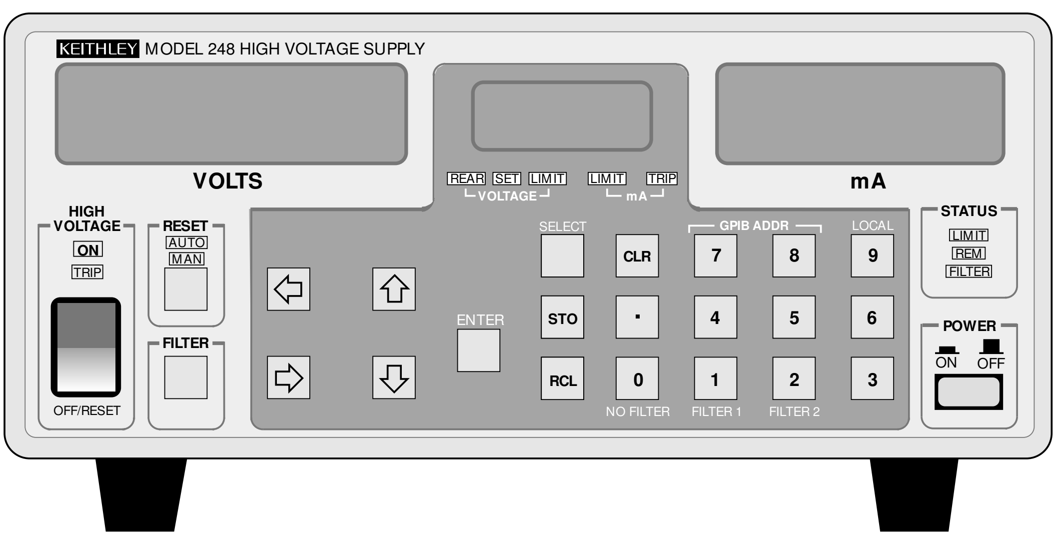


Figure 2-1
Model 248 front panel

POWER button

The Model 248 is turned on by depressing POWER ON. The unit always powers up with the high voltage OFF. All instrument settings are stored in nonvolatile memory and are saved when power is turned off. The model number, firmware version, and serial number are displayed when power is turned on. If an error occurs when powering up, the stored settings are lost, and the default settings are used. If the default settings are desired, hold down the CLR (clear) key while turning on the power.

HIGH VOLTAGE enable switch

This switch is a three-position switch that performs several functions. In the OFF/RESET position, the high voltage is off, and all trips are cleared. In this position, the high voltage is locked off and cannot be turned on by computer control. The ON position is a momentary-contact position and turns on the high voltage for manual or rear panel analog control. Note that the switch should be held in the ON position for at least one-half second to turn the high voltage on. In the middle position, the high voltage is enabled and can be turned on by commands sent over the IEEE-488 bus. The ON LED above the switch indicates that the high voltage is on; the yellow TRIP LED indicates a trip has occurred.

LED displays

The VOLTS and mA displays show output voltage and current respectively to four significant places. Polarity is displayed at the left of the voltage display. Note that these two displays will take about one second to update to a new value after a change in voltage or current.

The smaller center display shows the value of the parameter that is being entered or adjusted. This parameter is indicated by the row of LEDs directly below the center display.

SELECT, ENTER, and CLR

The SELECT key is used to choose which parameter is being displayed in the center display. The ENTER key enters the parameter shown in the center display. The CLR (clear) key erases the value in the center display and recalls the last value that was entered. To adjust a value, press the SELECT key until the appropriate LED is lit. While the value is being changed, the appropriate LED will flash to indicate that the value in the center display is not the present unit setting. If an incorrect value is entered, press CLR (clear) to start over. When the desired value is in the center display, press the ENTER key to update the unit's actual setting, and the LED will stop flashing.

Numeric and cursor keys

All parameters are adjusted using the cursor or numeric keys. When using the cursors, the digit being adjusted in the center display will flash. The up and down arrow keys increment and decrement the digit, while the left and right arrow keys select the flashing digit. When using direct numerical entry, press the number and decimal point keys until the desired value appears on the center display. Note that the current is specified in mA.

STATUS indicators

Three LEDs indicate the instrument's status. The LIMIT LED is on when the unit is in current limit. The REM LED is on when the unit is in remote, and the front panel is locked out. The FILTER LED is on when one of the two available output filters is enabled.

RESET

RESET sets the reset mode to either AUTO or MAN (manual). In the AUTO mode, the unit will automatically reset itself after a current limit trip. In the MAN mode, the unit must be manually reset when a trip occurs.

FILTER keys

The output filter, which may be used to reduce output ripple and noise, is controlled with the FILTER, NO FILTER, FILTER 1, and FILTER 2 keys. Filter 1 and Filter 2 may be selected by first pressing the FILTER key. At the FIL display prompt, press the FILTER 1 or FILTER 2 key to select Filter 1 or Filter 2 respectively, and then press ENTER. The associated FILTER LED will turn on to indicate that the filter is enabled. Press FILTER then NO FILTER followed by ENTER to turn off filtering.

Note that the noise reduction characteristics for the two filters are identical, but other factors such as rise and discharge times virtually depend upon the selected filter (see specifications). Also, note that the output with Filter 1 enabled is limited to 3kV at 5mA, while enabling Filter 2 restricts the output to 5kV at 3mA. Changing filter status turns off the high voltage.

GPIB ADDR keys

The GPIB ADDR keys set the GPIB primary address. To enter the GPIB address mode, press both keys simultaneously and then increment or decrement the address as required using the up and down arrow keys. The allowable primary address range is from 0 to 30. See Section 3 for more details on IEEE-488 bus operation.

LOCAL

The LOCAL key takes the instrument out of remote and restores operation of other front panel controls. The REM LED indicates when the unit is in remote.

STO and RCL

STO (store) and RCL (recall) allow up to nine complete instrument settings to be saved in nonvolatile memory. RCL 0 recalls the default settings.

2.5 Rear panel summary

Figure 2-2 shows the Model 248 rear panel. The various controls are explained in the following paragraphs.

Power entry module

The power entry module contains the line fuse, selects the line voltage, and includes filtering to block high-frequency noise from entering or exiting the unit. Refer to paragraph 2.3 for instructions on selecting the correct line voltage and fuse.

HIGH VOLTAGE output connector

The HIGH VOLTAGE output connector is an SHV male connector that connects the Model 248 source output to external equipment. SHV-to-SHV and SHV-to-MHV mated high voltage cables are available.

WARNING

This unit contains hazardous voltages. Be certain that the high voltage is completely discharged before removing or connecting the high voltage cable. High voltage cables can store charge if they are disconnected from the supply while high voltage is turned on, and can cause personal injury or death if not handled properly. Use only connecting cables with a rated working voltage of 5kV or higher.

Do not connect the HIGH VOLTAGE output to exposed circuitry. Any load connected to the HIGH VOLTAGE output should be enclosed in a metal shield that is connected to safety earth ground using #18AWG or larger wire.

Figure 2-3 shows typical high voltage output connections.

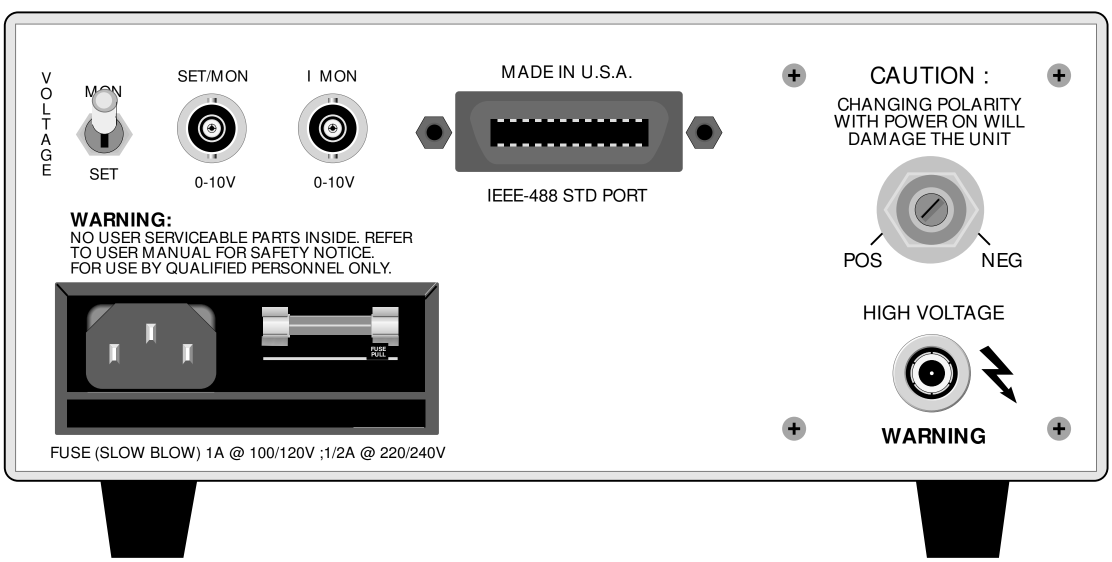


Figure 2-2
Model 248 rear panel

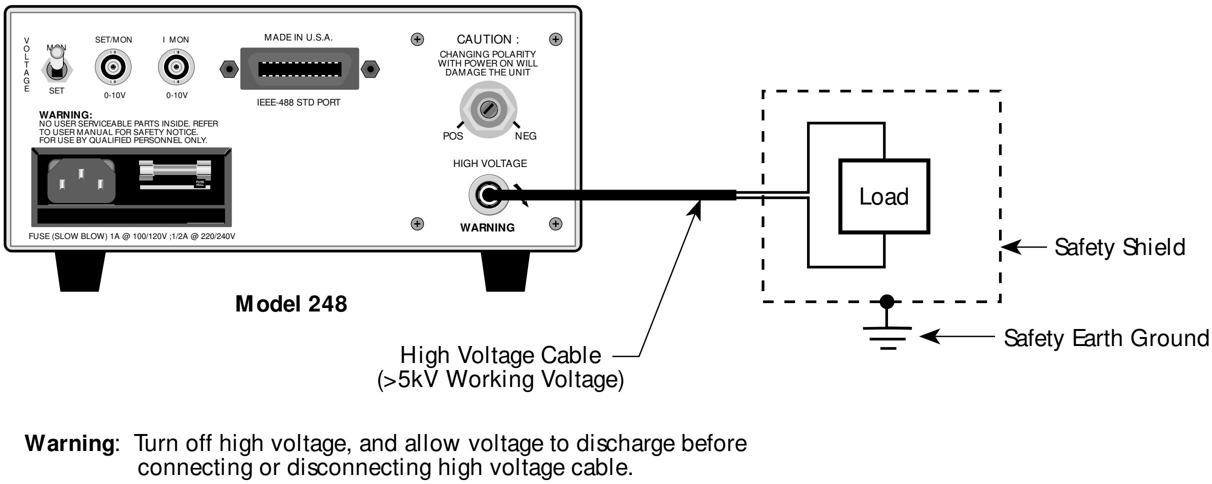


Figure 2-3
Typical high voltage connections

High voltage polarity selector

The high voltage polarity selector switch selects the polarity of the source output voltage.

Polarity is indicated by the position of the screwdriver slot on the polarity switch as well as on the front panel voltage display. To reverse the polarity, turn the unit off, and allow the high voltage to completely discharge. Turn the polarity switch with a large flathead screwdriver (clockwise for POS to NEG and counterclockwise for NEG to POS).

CAUTION

The high voltage must be turned off and completely discharged before reversing the polarity. Failure to do so will result in damage to the unit.

Analog outputs

The SET/MON and I/MON BNC jacks provide voltage and current monitor signals, or an external voltage control input and current monitor, depending upon the setting of the VOLTAGE select switch.

When the VOLTAGE select switch is in the MON (monitor) position, both jacks are 0 to +10V outputs corresponding to 0 to full scale. For example, if the voltage source output is 2kV, the SET/MON jack output voltage will be 4V.

When the voltage select switch is in the SET position, the I/MON jack remains an output signal, but the SET/MON jack becomes an input signal and sets the high voltage source value over the same range as the control voltage input. For example, a 2V analog voltage input results in a 1kV source output voltage. When the switch is in the SET position, the REAR LED on the front panel is lit, indicating that high voltage is under analog control and cannot be adjusted from the keypad. All signals are positive voltages, independent of output voltage polarity.

Figures 2-4 and 2-5 show example analog output connections.

WARNING

The BNC jack outer shells are connected to chassis ground and cannot be floated.

IEEE-488 STD PORT

The 24-pin IEEE-488 (GPIB) connector allows computer control of the Model 248. The primary address is set from the front panel using the GPIB ADDR keys. Refer to Section 3 for detailed IEEE-488 programming information.

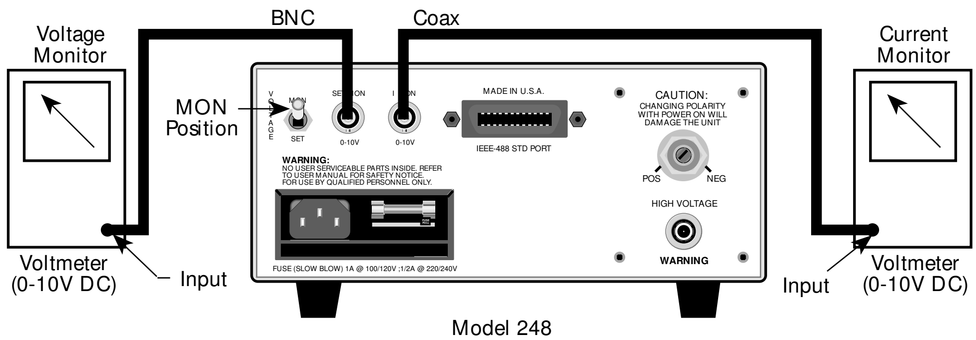


Figure 2-4
Voltage monitor, current monitor connections

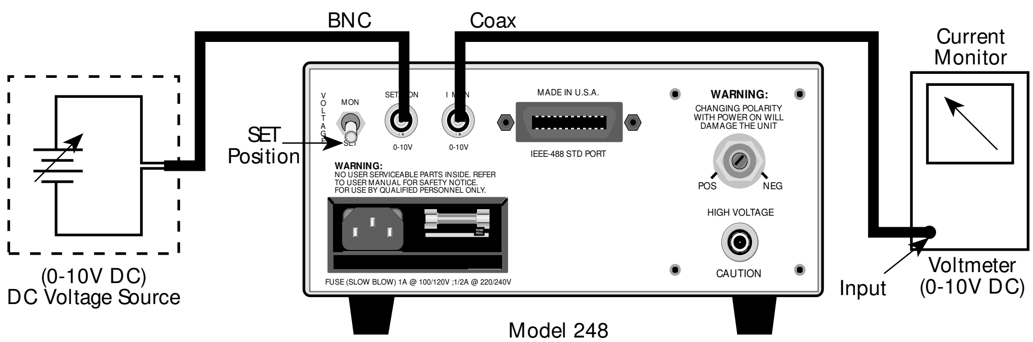


Figure 2-5
Voltage set, current monitor connections

2.6 Guide to operation

2.6.1 Setting the output voltage

The voltage setting can be changed with the high voltage on or off. The basic procedure is as follows:

1. Press the SELECT key until the VOLTAGE SET LED is on. The present voltage setting will appear on the center display.
2. To change the voltage setting, enter the desired voltage using either the numeric or cursor keys. After the new value has been entered into the center display, press ENTER to update the output voltage.
3. The VOLTAGE SET LED will flash until ENTER or CLR is pressed to remind you that the displayed value is not the actual programmed value.
4. If an Err2 message appears (illegal parameter entered), check the voltage limit to see that it is greater than or equal to the desired set voltage. Use the CLR key to clear any error message.

NOTE

If the REAR LED is on, the high voltage is programmed from the voltage applied to the analog input on the rear panel. In this mode, the high voltage cannot be programmed from the front panel, and the center display will show the actual output voltage in the VOLTAGE SET mode.

2.6.2 Setting the voltage limit

The voltage limit is a protection feature intended to prevent the output voltage from being set too high or from overshooting because of large load changes. The output voltage cannot be set higher than the voltage limit. In addition, if the output voltage ever exceeds the programmed limit by more than 10% of full scale, the trip point is reached, and the high voltage is disabled. In this case, a VTRP (voltage trip) message appears on the center display.

NOTE

It is not necessary to clear the trip before turning the high voltage back on. If it is necessary to change a parameter before turning the high voltage back on, pressing CLR or placing the high voltage switch in the off position will clear the trip.

Set the voltage limit as follows:

1. Press the SELECT key until the VOLTAGE LIMIT LED is lit. The present value of the voltage limit is shown on the center display.
2. Change the limit value using either the numeric or cursor keys, and press ENTER to update the actual limit value.
3. If an Err2 message appears (illegal parameter entered), check to see that the output voltage is less than or equal to the voltage limit.

2.6.3 Setting the current limit

Current limiting varies the output voltage to limit the output current to less than or equal to the programmed current limit value. When the unit is current limited, the STATUS LIMIT LED is on.

Set the current limit as follows:

1. Press the SELECT key until the mA LIMIT LED is on. The present value of the current limit is shown on the center display.
2. Change the limit value using either the numeric or cursor keys, and press ENTER to update the actual limit value.

2.6.4 Setting the current trip

The current trip shuts off the high voltage when the output current exceeds the trip value. The current trip value is set in the same manner as the voltage and current limits. After a current trip occurs, the ITRP (current trip) message will appear on the middle display. Current trips are cleared in the same fashion as voltage trips.

Set the current trip as follows:

1. Press the SELECT key until the mA TRIP LED is on. The present value of the current trip is displayed in the center window.
2. Change the limit value using either the numeric or cursor keys, and press ENTER to update the actual trip value.

2.6.5 Primary trip

A PTRP (primary trip) message will occur if the current through the primary side of the high voltage transformer and the switching MOSFETs exceeds 5.3A. This feature is included to protect the transformer and FETs. The primary trip level is not user programmable and may be cleared in the same manner as the voltage and current trips. If repeated primary trips occur, refer to Section 5.

2.6.6 Reset mode

The reset mode determines how the unit responds after a voltage or current trip.

MAN (manual) Mode — The high voltage remains off after a trip and requires that the operator manually turn it back on.

AUTO (automatic) Mode — The unit waits until the output voltage has fallen to 2% of its full-scale value and then turns the high voltage back on. This feature is useful when dealing with loads that occasionally short circuit but recover after high voltage has been removed.

2.6.7 Store and recall

STO (store) and RCL (recall) allow up to nine complete instrument setups to be saved and later recalled.

To store a setup:

1. Program the various instrument operating modes to be stored.
2. Press the STO key.
3. Press a number (1-9) to select the desired storage location.
4. Press the ENTER key to complete the storage process.

To recall a setup:

1. Press the RCL key.
2. Press the number key (0-9) for the configuration to be recalled. (RCL 0 returns the instrument to the factory default setup.)
3. Press the ENTER key.

Notes:

- Whenever a setup is recalled, the high voltage is turned off for safety.
- If an Err3 (recall error) occurs, the stored setup was lost due to a memory error and must be stored again using the STO key.

2.6.8 Output filter

The Model 248 employs a switchable output filter for low-noise performance. If higher slew rate or output power is required, the filter can be switched out. When the filter is in, the unit can reach either maximum voltage or maximum current but not both simultaneously. The filter has three possible settings: Filter Out (Filter 0); Filter In, High Current (Filter 1); and Filter In, High Voltage (Filter 2).

The output filter determines the voltage and current limits, as well as the ripple and noise performance of the unit. See the specifications for information on ripple and noise for the different filter settings. The voltage and current limits for the different filter settings are listed in Table 2-1.

If the filter is changed while the high voltage is on, the unit will turn off the high voltage and wait until the voltage has dropped below |100| VDC before switching the filter. This is done to minimize stress on the filter components. During this time, the HIGH VOLTAGE ON switch is disabled until the filter has finished changing. If the filter is changed while the high voltage is off, it will switch immediately.

To display the present filter value, press the FILTER key. To enter a new filter value, enter the value, followed by the ENTER key. If an illegal value is entered, the unit will display Err2 (illegal parameter entered). Use the CLR key to clear any error messages.

Table 2-1
Filter limits

Filter mode	Voltage limit	Current limit	Current trip
Filter Out (Filter 0)	5000 VDC	5.00 mA	5.00 mA
High Current Filter (Filter 1)	3000 VDC	5.00 mA	5.00 mA
High Voltage Filter (Filter 2)	5000 VDC	3.00 mA	3.00 mA

2.6.9 Error and status messages

Error messages that may appear on the center display are summarized in Table 2-2. Note that the CLR key clears any errors. See GPIB error messages in Section 3 for more information on GPIB errors. Table 2-3 summarizes status messages.

Table 2-2
Error messages

Error number	Description	Comments
Err1	Memory Error	Power-on memory error of the last setup. Default setup is recalled.
Err2	Illegal Parameter Entered	Parameter entered is out of range.
Err3	Stored Value Recall Error	The stored setup (from STO and RCL) was lost.
Err4	Illegal Storage Address	STO 0 is reserved for default settings.
Err5	No GPIB Interface	GPIB interface not detected, and the GPIB address cannot be set.
Err6	Syntax error over GPIB	Invalid command.
Err7	Illegal parameter sent over GPIB	Parameter programmed is out of range.
Err8	GPIB Output queue full	Output buffer overflowed.

Table 2-3
Status messages

Message	Description
VTRP	Voltage trip (voltage limit exceeded)
ITRP	Current trip (current limit exceeded)
PTRP	Primary trip (power transformer primary current limit exceeded)

2.6.10 Analog programming and monitor

The rear panel VOLTAGE select switch determines whether the output voltage is set from the front panel or from the rear panel SET/MON input. If the switch is in the MON (monitor) position, the front panel controls the voltage. If the switch is in the SET position, the rear panel analog voltage will control the output voltage.

When the VOLTAGE switch is in the SET position, the REAR (rear panel) LED is on, and the output voltage is controlled by the rear panel signal and displayed on the center display when in the VOLTAGE SET mode. The voltage limit is still active, and the unit does not allow the rear panel voltage to set the output value above the voltage limit.

NOTE

If the switch position is changed while the high voltage is on, the unit will turn off the high voltage.

Voltage Monitor: When the VOLTAGE switch is in the MON position, the SET/MON jack is a monitor output providing 0 to +10V for 0 to full-scale output regardless of polarity. When the switch is in the SET position, this BNC jack becomes an input over the same range. An input of 0 to +10V will set the output voltage from 0 to full scale regardless of polarity. Table 2-4 lists voltage monitor examples, and Table 2-5 summarizes analog input voltage examples.

Table 2-4
Analog monitor examples

Output voltage	Analog monitor examples
1kV	2V
3.5kV	7V
-5kV	10V
-2.5kV	5V

Table 2-5
Analog input voltage examples

Analog input voltage	High voltage output
2V	1kV
5V	2.5kV
6V	3kV
10V	5kV

Current Monitor: The I/MON jack provides a 0 to +10V signal for 0 to full-scale current output regardless of the output polarity. Table 2-6 summarizes current monitor output examples.

Table 2-6
Current monitor examples

Current output	Current monitor
1mA	2V
2.5mV	5V
3.5mA	7V
5mA	10V

2.6.11 Default setup

The factory default setup can be recalled by pressing the CLR key while turning on the power or by recalling setup 0 (RCL 0). The default setup is also recalled after a power-on memory error (Err 1). Table 2-7 lists the factory default setup.

Table 2-7
Default setup

Mode	Default setting
Output Voltage	0V
Voltage Limit	5000V
Current Limit	5.25mA
Current Trip	5.25mA
Reset Mode	MAN
High Voltage	OFF
GPIB Address	14
Filter	OFF

3

IEEE-488 Programming

3.1 Introduction

This section contains detailed information on remotely programming the Model 248 over the IEEE-488 (GPIB) interface. Any computer that supports the IEEE-488 bus may be used to program the instrument. The Model 248 supports the IEEE-488.1 (1978) interface standard as well as the required common commands of the IEEE-488.2 (1987) standard.

3.2 Bus connections

With the power off, connect the Model 248 GPIB connector to the computer IEEE-488 interface. Shielded GPIB cables such as the Keithley Model 7007 are recommended.

3.3 Primary address

Before attempting to communicate with the Model 248 over the IEEE-488 interface, make sure the instrument's primary address is set correctly. Press both GPIB ADDR keys simultaneously to set the address to the desired value between 0 and 30. Be sure to avoid address conflicts with other instruments on the bus, including the controller.

3.4 Command syntax

Commands sent to the Model 248 use ASCII characters. Commands may be in either upper or lower case and may contain any number of embedded space characters.

A command to the Model 248 consists of a four-character command mnemonic and a command terminator. The terminator is a linefeed (<LF>) or EOI. No command processing occurs until a command terminator is received. Command mnemonics beginning with an asterisk (*) are IEEE-488.2 defined common commands. Commands may require one or more parameters; multiple parameters must be separated by commas (,).

3.4.1 Multiple commands

Multiple commands may be sent on one command line by separating them with semicolons (;). When several commands are included on the same line, the entire line is parsed and executed before any other device action proceeds. This method allows command synchronization using the synchronization commands.

3.4.2 Command buffer

The Model 248 has a 256-character input buffer and processes commands in the order received. Therefore, it is not necessary to wait between commands. If the buffer becomes full, the Model 248 will hold off bus handshaking until commands are processed. Similarly, the unit has a 256-character output buffer to store output data until the host computer is ready for reception. If the output buffer becomes full, it is cleared, and an appropriate error is reported.

3.4.3 Command queries

The present value of a particular parameter may be determined by querying the Model 248 for its value. A query is formed by appending a question mark (?) to the command mnemonic and omitting the desired parameter from the command. If multiple queries are sent on one command line (separated by semicolons), responses will be returned in a single line with the individual responses separated by semicolons. The default response terminator is a linefeed plus EOI. All commands return integer results except as noted in individual command descriptions.

3.4.4 Command examples

VSET1.0E3	Set voltage to 1000V.
VSET?	Query voltage setting.
*IDN?	Query device identification.
VSET100.0;VSET?	Set voltage to 100V and query voltage.

3.5 Detailed command description

Table 3-1 summarizes Model 248 commands. The four-letter mnemonic in each command sequence specifies the command, and the rest of the sequence consists of parameters. Multiple parameters are separated by commas. Commands with queries have a question mark in parentheses (?) after the mnemonic. Commands that have only a query have a "?" after the mnemonic. Commands that cannot be queried have no question mark. Brackets [ ] indicate the parameter is optional. An asterisk (*) preceding the mnemonic indicates IEEE-488.2 common commands.

NOTE

Parentheses shown in command descriptions indicate only that a query form is available. Do not include parentheses in commands.

Table 3-1
Command summary

Type	Command	Description
Output Control	HVOF	Turn off high voltage.
	HVON	Turn on high voltage.
	IOUT?	Query output current value.
	VOUT?	Query output voltage value.
Setting Control	*RCL <n>	Recall stored setting <n>.
	*SAV <n>	Save setting <n>.
	ILIM(?) <n>	Set current limit to <n>.
	ITRP(?) <n>	Set trip current to <n>
	SMOD?	Query VSET mode.
	TCLR	Clear voltage/current trips.
	TMOD(?) <n>	Set trip reset mode.
	VLIM(?) <n>	Set voltage limit to <n>.
	VSET(?) <n>	Set voltage output to <n>.
	FILT(?) <n>	Set filter to <n>.
Interface Control	*RST	Reset to default setup.
	*IDN?	Query device ID.
	*WAI	Halt command for synchronization.
Status Reporting	*CLS	Clear status registers.
	*ESE(?) <n>	Set status byte enable register.
	*ESR? [<n>]	Read status register.
	*PSC(?) <n>	Set power-on status clear bit.
	*SRE(?) <n>	Set service request enable register.
	*STB? [<n>]	Query status byte.

A question mark in parentheses (?) indicates that the command also has query form. Do not include parentheses in command. Commands with a question mark not in parentheses have only a query form.

Brackets [ ] indicate that parameter is optional.

An asterisk (*) preceding the mnemonic indicates IEEE-488.2 common commands.

3.5.1 Output control commands

HVOF — The HVOF command turns off the high voltage output.

HVON — The HVON command turns on the high voltage provided that the front panel HIGH VOLTAGE switch is not in the OFF position. If the switch is in the OFF position, the high voltage is left off, and an execution error is reported. This command also automatically clears any voltage or current trips.

IOUT? — The IOUT? query returns the value of the actual output current. This value is the same as that shown on the front panel mA display.

NOTE

As with the front panel display, this value takes about one second to stabilize after a change in current.

VOUT? — The VOUT? query returns the actual output voltage. This value is the same as that shown on the front panel VOLTS display. The value returned is a floating-point number and includes the sign of the output voltage.

NOTE

As with the front panel voltage display, this value takes about one second to stabilize after a change in voltage.

3.5.2 Setting control commands

***RCL <n>** — The *RCL (Recall) command recalls stored configuration setting <n>, where <n> ranges from 0 to 9. Setting 0 recalls the default settings. If the stored setting is corrupted, an error is returned.

Example: *RCL 0 Recall default setting.

***SAV <n>** — The *SAV (Save) command stores the present instrument setup as setting <n>, where <n> ranges from 1 to 9.

Example: *SAV 3 Save setting #3.

ILIM(?) <n> — The ILIM command sets the value of the current limit to <n>, where <n> is a floating-point value in amperes. The ILIM? query returns the current limit setting.

Example: ILIM 1E-3 Set 1mA current limit.

ITRP(?) <n> — The ITRP command sets the value of the current trip to <n>, where <n> is a floating-point value in amperes. The ITRP? query returns the current trip setting.

Example: ITRP 1E-3 Set 1mA trip current.

SMOD? — The SMOD? query returns the VSET setting mode. A returned value of 0 indicates that the voltage value is controlled by the front panel or bus setting, while the value 1 indicates that the output is controlled by the rear panel SET/MON voltage control input. Note that the setting mode may only be changed by setting the rear panel VOLTAGE switch.

TCLR — The TCLR command clears any voltage or current trips.

TMOD(?) <n> — The TMOD command sets the trip reset mode. The value <n> = 0 sets manual trip reset, while the value <n> = 1 sets the trip reset mode to auto.

VLIM(?) <n> — The VLIM command sets the value of the voltage limit to <n>, where <n> is in volts. The sign of <n> must match the Model 248's polarity setting, or a syntax error will occur. The VLIM? query returns the present limit setting. As with front panel control, the VLIM value must be greater than or equal to the VSET value, or an execution error will occur.

Example: VLIM 500 Set 500V voltage limit.

VSET(?) <n> — The VSET command sets the voltage output to <n> if front panel control is enabled. If rear panel control is enabled, an error is returned. The value <n> is in volts, and the sign must match the polarity setting or a syntax error will occur. The VSET? query returns the current VSET value. As with front panel control, the VSET value must be less than or equal to the VLIM value, or an execution error will occur.

Example: VSET 2500 Set output to 2.5kV.

FILT(?) <n> — The FILT command controls the output filter, which is useful for reducing output ripple and noise. When <n> = 0 the output filter is disabled, while <n> = 1 and <n> = 2 enable Filter 1 and Filter 2, respectively. The FILT? query returns the state of the filter.

Example: FILT 1 Enable Filter 1.

NOTE

When the filter is changed, the high voltage is turned off. The unit does not actually change the filter until the high voltage has dropped below |100| VDC. If the high voltage is turned on remotely while the filter is in the process of changing, an error will result. So if the commands FILT1;HVON are sent, an Err7 (illegal GPIB command) will appear. To avoid this situation, insert a *WAI (wait command) between the two. The command string FILT1;*WAI;HVON is legal.

3.5.3 Interface control commands

***RST** — The *RST (Reset) common command resets the Model 248 to its default configuration. This command performs the same function as holding down the front panel CLR key at power-on.

***IDN?** — The *IDN? (Identification) common query returns the Model 248 device configuration. The response string is in the format:

Keithley Model 248, <serial_number>, <version_number>

Where:

248 is the model number.
serial_number is the serial number of the particular unit.
version_number is the 3-digit firmware version level.

***WAI** — The *WAI common command is a synchronization command that halts further command processing until all present commands are complete. For example, the commands FILT1;*WAI;HVON would change the output filter setting, wait until the operation was complete, and turn the high voltage back on.

3.5.4 Status reporting commands

The following commands control various status reporting aspects. See paragraph 3.6 for more information on using these status commands.

***CLS** — The *CLS (Clear Status) common command clears all status registers.

***ESE(?) <n>** — The *ESE common command sets the Standard Event Status Enable Register. The parameter <n> is the decimal value that programs the enable register (see Table 3-3).

Example: *ESE 12 Set bits 2 and 3.

***ESR? [<n>]** — The *ESR? common query reads the value of the Standard Event Status Register. If the parameter <n> is present, the value of bit <n> is returned. Reading this register without specifying <n> will clear the register, but reading bit <n> will clear only bit <n>.

Example: ESR? 4 Request and clear bit 2.

***PSC(?) <n>** — The *PSC (Power-on Status Clear) common command sets the value of the power-on status clear bit. If <n> = 1, the power-on status clear bit is set, and all status registers and enable registers are cleared on power-up. If <n> = 0, the bit is cleared, and the status enable registers maintain their values at power-down. This feature allows the generation of a service request at power-up.

Example: *PSC 1 Set power-on status clear bit.

***SRE(?) <n>** — The *SRE (Service Request Enable) common command sets the value of the Service Request Enable Register. The parameter <n> is the decimal value representing the register bits to be set. (See Table 3-2.)

Example: *SRE 3 Set bits 0 and 1.

***STB? [<n>]** The *STB? (Status Byte) common query reads the value of the Status Byte Register. If the parameter <n> is included, the value of bit <n> is returned. Reading this register has no effect on its value; it only represents the summary of the other status registers.

Example: *STB? 2 Request bit 1 status.

3.6 Status reporting

The Model 248 reports on its status with two registers: the Status Byte Register and the Standard Event Status Register. The overall configuration of these registers is shown in Figure 3-1. Note that bits 0, 1, and 8 through 15 of both the Standard Event Status Register and Standard Event Status Enable Register are not used in the Model 248 and are always set to zero.

On power-up, the 248 will either clear all of its status enable registers or maintain them in the state they were in during power-down. The action taken is controlled by the *PSC command and allows events such as SRQ on power-up to be generated if desired.

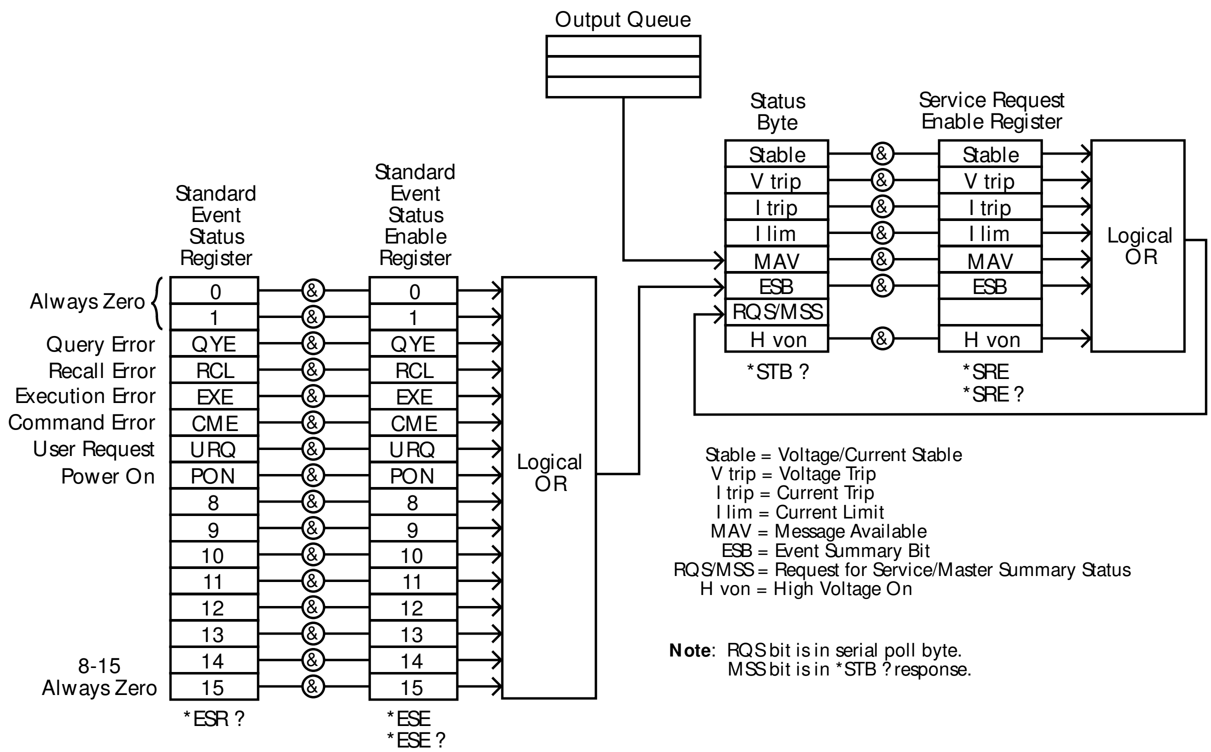


Figure 3-1
Status model

3.6.1 Status byte register

Table 3-2 summarizes bits in the Status Byte, which may be read with the *STB? query or with the serial polling sequence. The Model 248 will generate a service request (SRQ) whenever one of these bits is set and the corresponding bit in the Service Request Enable Register is set, except for bit 6, the RQS/MSS bit. (Use the *SRE command and the decimal bit value in the table to set Service Request Enable Register bits.) Note that any given status condition will produce only one SRQ even if that condition is never cleared.

The V trip, I trip, and I lim bits are latched bits. They are set on the occurrence of the appropriate event and will remain set until either the status byte is read or the *CLS command is sent. Latching allows you to detect if a trip or limit condition has ever occurred. The remaining bits do not latch; they indicate the current states of their respective functions.

3.6.2 Standard event status register

Table 3-3 summarizes the bits in the Standard Event Status Register, which can be read using the *ESR? query. This status register is defined by the IEEE-488.2 standard and is used primarily to report errors in commands received over the GPIB. The bits in this register stay true once set and are cleared by reading them, or by sending the *CLS command. If a bit in the Standard Event Status Register is set and the corresponding bit in the Standard Event Status Enable Register (programmed with *ESE) is also set, the ESB bit in the Status Byte Register is set.

Table 3-2
Status byte

Bit	Decimal value	Name	Description
0	1	Stable	Indicates that the VSET or ILIM value is stable. The function depends on whether the Model 248 is in constant current or constant voltage mode.
1	2	Vtrip	Indicates that a voltage trip has occurred.
2	4	I trip	Indicates that a current trip has occurred.
3	8	I lim	Indicates that a current limit condition has occurred.
4	16	MAV	Indicates message available in the GPIB output queue.
5	32	ESB	Indicates that an unmasked bit in the Standard Event Status Register has been set.
6	64	RQS/MSS*	Request for Service/Master Summary Status
7	128	Hvon	Indicates that the high voltage is on.

Note: SRQ may be enabled for corresponding condition by sending *SRE with decimal value of bit (except bit 6).
For example, *SRE 4 enables SRQ on current trip.
*Request for Service bit in serial poll byte. Master Summary Status bit in *STB? response.

Table 3-3
Standard event status register

Bit	Decimal value	Name	Description
0	1	Unused	
1	2	Unused	
2	4	Query Error	Set by an output queue overflow.
3	8	Recall Error	Set if a stored configuration setting is corrupt.
4	16	Execution	Set by an out-of-range parameter, or non-completion of a command due to a condition such as an overload.
5	32	Command Error	Set by a command syntax error or unrecognized command.
6	64	URQ	Set by any key press.
7	128	PON	Set by power-on.

Note: Set ESB bit in Status Byte Register by sending *ESE command with desired condition.
For example, *ESE 16 sets ESB on execution error.

3.7 GPIB error messages

The following error messages will appear on the center display if an error caused by a command sent over the GPIB occurs. These errors also set corresponding bits of the Standard Event Status Register.

3.7.1 Err6 (Syntax Error over GPIB)

Err6 indicates the command had an error in syntax or was unrecognizable. A syntax error could be a misspelling of a command or forgetting to include a '–' when setting a negative value for the voltage or voltage limit. This error will set the Command Error bit (bit 5) of the Standard Event Status Register.

3.7.2 Err7 (Illegal Parameter entered over GPIB)

Err7 indicates a parameter was set out of range, or a command could not be completed because of an overload. This error will set the Execution Error bit (bit 4) of the Standard Event Status Register.

3.7.3 Err8 (GPIB output queue full)

Err8 indicates the output queue overflowed and was cleared. This error could be caused by querying the unit repeatedly and not reading out all of the characters, or by a problem at the receiving unit. This error will set the Query Error bit (bit 2) of the Standard Event Status Register.

3.8 Program examples

The following example programs use the IEEE-488 interface to control the Model 248. These two programs set up the Model 248 to ramp the output voltage from 10V to 1000V while monitoring the output current. The unit is programmed to generate an SRQ when the output voltage is stable, and a subroutine or function tests for an SRQ during each program loop.

Examples are provided for both QBasic and Turbo C.

3.8.1 Computer hardware requirements

The following computer hardware is required to run the example programs:

- IBM PC, AT, or compatible computer.
- Keithley KPC-488.2, KPS-488.2, or KPC-488.2AT, or CEC PC-488 IEEE-488 interface for the computer.
- Shielded IEEE-488 connecting cable (Keithley Model 7007)

3.8.2 Computer software requirements

In order to use the example programs, you will need the following software:

- Microsoft QBasic (Program 1) or Borland Turbo C (Program 2).
- MS-DOS version 5.0 or later.
- HP-style Universal Language Driver, CECHP.EXE (supplied with Keithley and CEC interface cards listed above).

3.8.3 General program instructions

1. With the power off, connect the Model 248 to the IEEE-488 interface of the computer. Be sure to use a shielded IEEE-488 cable such as the Keithley Model 7007 for bus connections.
2. Turn on the computer and the Model 248.
3. Make sure the Model 248 is set for a primary address of 23. (Use the front panel GPIB ADDR keys to check or change the address.) Also make sure the front panel HIGH VOLTAGE enable switch is not in the OFF/RESET position.
4. Make sure that the computer's IEEE-488 bus driver software (CECHP.EXE) is properly initialized.
5. Enter the QBasic or Turbo C editor, and type in the following desired program. Check thoroughly for errors, and then save it using a convenient filename.
6. Run or compile the program, and note that the output voltage ramps from 10-1000V while the current at each voltage step is displayed on the computer screen.

3.8.4 Program example 1, Q Basic

```
' Example program to ramp output voltage 10-1000V and read current.
' Program uses QBasic and Keithley or CEC IEEE-488 interface card.
' Requires IEEE-488 bus driver CECHP.EXE.
' Model 248 Primary Address = 23.
'
OPEN "IEEE" FOR OUTPUT AS #1            ' Open IEEE-488 output path.
OPEN "IEEE" FOR INPUT AS #2             ' Open IEEE-488 input path.
PRINT #1, "INTERM CRLF"                 ' Set input terminator.
PRINT #1, "OUTTERM LF"                  ' Set output terminator.
PRINT #1, "REMOTE 23"                   ' Put 248 in remote.
PRINT #1, "OUTPUT 23;*SRE 1"            ' Enable SRQ when stable.
'
Voltage = 0                             ' Initial voltage = 0V.
PRINT #1, "OUTPUT 23;HVON"
DO: Voltage = Voltage + 10              ' Increment output voltage by 10V.
        PRINT "Voltage  = "; Voltage
        PRINT #1, "OUTPUT 23;VSET "; Voltage ' Program output voltage.
        GOSUB Stable
        PRINT #1, "OUTPUT 23;IOUT?"     ' Query output current.
        PRINT #1, "ENTER 23"            ' Address 248 to talk.
        INPUT #2, Current               ' Input current.
        PRINT "Output current = "; Current
        PRINT
LOOP WHILE Voltage < 1000               ' Loop until 1000V is reached.
PRINT #1, "OUTPUT 23;HVOF"              ' Turn off high voltage.
PRINT #1, "LOCAL 23"                    ' Return to local control.
END
'
Stable:                                 ' Output voltage stable routine.
DO
        PRINT #1, "SRQ?"                ' Get SRQ status.
        INPUT #2, SRQ
LOOP UNTIL SRQ                          ' Loop until SRQ is detected.
PRINT #1, "OUTPUT 23;*CLS"              ' Clear SRQ.
RETURN
```

3.8.5 Program example 2, Turbo C

```
/* Example program ramps voltage 10-1000V and reads output current.
   Uses Turbo C and Keithley or CEC IEEE-488 interface card.
   Requires IEEE-488 bus driver CECHP.EXE.
   Model 248 Primary Address = 23. */

#include <stdio.h>

#define MAX 1000
#define INC 10

void stable(void);
FILE *ieeein,*ieeeout;

main()
{

   float current=0;
   int voltage=0;

/* Initialize interface and Model 248. */

   if ((ieeein=fopen("IEEE","r"))==NULL) {
      printf("Cannot open IEEE-488 bus I/O.\n");
      exit(1);
         }
   ieeeout=fopen("IEEE","w");
   setbuf(ieeein,NULL);
   setbuf(ieeeout,NULL);
   fprintf(ieeeout,"interm crlf\n");
   fprintf(ieeeout,"outterm lf\n");
   fprintf(ieeeout,"remote 23\n");
   fprintf(ieeeout,"output 23;*sre1\n");

/* Program voltage and read current. */

   fprintf(ieeeout,"output 23;hvon\n");
   do {
      voltage += INC;
      printf("Voltage = %d\n",voltage);
      fprintf(ieeeout,"output 23;vset %d\n",voltage);
      stable();
      fprintf(ieeeout,"output 23;iout?\n");
      fprintf(ieeeout,"enter 23\n");
      fscanf(ieeein,"%f",&current);
      printf("Current = %f\n\n",current);
   }
   while (voltage < MAX);
   fprintf(ieeeout,"output 23;hvof\n");
   fprintf(ieeeout,"local 23\n");
}

/* Stable function detects SRQ when stable */

void stable(void)
{
   int srq=0;
   do {
```

```
      fprintf(ieeeout,"srq?\n");
      fscanf(ieeein,"%d",&srq);
   }
   while(srq==0);
   fprintf(ieeeout,"output 23;*cls\n");
}
```

4

Performance Verification

4.1 Introduction

This section contains procedures to verify the Model 248 meets or exceeds its stated performance specifications for DC voltage accuracy, DC current accuracy, load regulation, and output voltage ripple. These procedures should be performed when the instrument is first received to ensure that no damage has occurred during shipment.

WARNING

The procedures in this section are intended to be used by qualified service personnel only. Many of these 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. Use extreme caution when working with hazardous voltages.

4.2 Environmental conditions

All verification procedures should be performed at an ambient temperature of 18 to 28°C and at a relative humidity of 70% or less unless otherwise noted.

4.3 Warm-up period

The Model 248 should be turned on and allowed to warm up for at least 1 hour before performing the verification procedures. The test equipment should also be allowed to warm up for the time period recommended by the manufacturer.

4.4 Recommended test equipment

Table 4-1 summarizes recommended test equipment for the verification procedures.

Table 4-1
Recommended verification test equipment

Equipment	Specifications	Manufacturer and model
High-Voltage Divider	0.01% DC Accuracy	Julie Research KV-10/.01 or KV-10R
DC/AC Multimeter	0.002% DC Accuracy, 10GΩ DC Input Impedance True RMS AC to 100kHz	Keithley Model 2000
4.99kΩ Resistor	1%, 1W	Any suitable component
1MΩ Load Resistor	5kV, 25W	See Figure 4-2
5kV AC Coupling Network	0.01µF, 5kV, 5% Capacitor 2.00MΩ, 1% Resistor Two 1N4148 Diodes	See Figure 4-4
SHV "T" Coupler		

4.5 Verification procedures

The verification procedures are explained in detail in the following paragraphs. Refer to Table 4-1 and the respective diagrams for test equipment and connections. Note that each procedure is performed both with the output filter off and with Filter 1 enabled. Since the Model 248 hardware configuration is the same for both Filter 1 and Filter 2, only the Filter 1 configuration requires testing.

WARNING

The following procedures use high voltage. Use extreme care to avoid electrical shock that could result in personal injury or death. Do not touch any exposed circuitry while the high voltage is enabled.

High voltage cables can store charge even when disconnected from the unit. Always turn off the high voltage and make sure all cables and circuitry are completely discharged before connecting or disconnecting cables or other circuitry.

4.5.1 DC voltage accuracy

Use the following steps to measure the accuracy of the DC output voltage.

1. With the power off, connect the Model 248 HIGH VOLTAGE output connector to the high voltage divider, and connect the multimeter to the 1V output tap of the divider (see Figure 4-1.)

WARNING

Connect the divider chassis to safety earth ground using #18AWG or larger wire.

2. Turn on the power, and set the Model 248 to its default conditions. (Press RCL, 0, and then ENTER.)
3. Set the high-voltage output polarity to POS using the rear panel polarity switch.
4. Select the multimeter DCV function, and enable autoranging.
5. With the high voltage turned off, allow the multimeter reading to settle to 0V, and then enable the REL mode to null any residual offset voltage.
6. Turn on the Model 248 high-voltage output. Set the Model 248 output voltage to each value in Table 4-2, and verify that the reading parameters are within stated limits. For each setting:
   - Set the output voltage as indicated in the table.
   - Wait the indicated time.
   - Make sure that the Model 248 VOLTS display reading is within stated limits.
   - Verify that the multimeter reading is within required limits.
7. Turn off the high voltage, allow the voltage to discharge, and then set the rear panel polarity switch to the NEG position. Repeat step 6 for all voltages listed in the table.
8. Repeat the procedure with Filter 1 enabled for voltages up to 3000V. Be sure to test both with positive and negative output polarity.

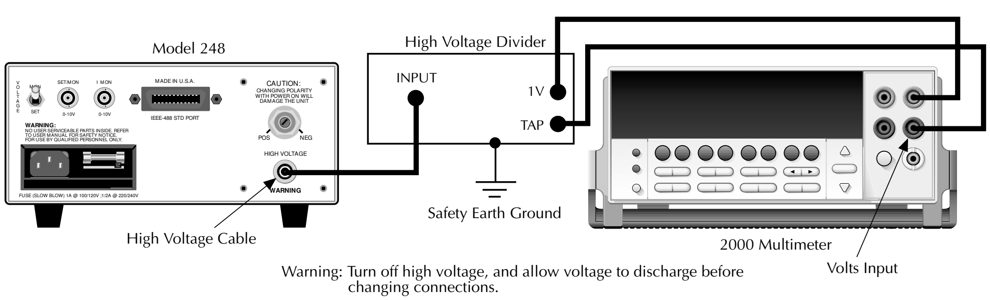


Figure 4-1
Connections for DC voltage accuracy tests

Table 4-2
DC voltage accuracy summary

Model 248 output voltage*	Wait prior to taking readings	Models 248 VOLTS display limits	Multimeter reading limits
5000V	30 min.	4998 to 5002V	4.997 to 5.003V
4000V	3 min.	3998 to 4002V	3.9971 to 4.0029V
3000V	3 min.	2998 to 3002V	2.9972 to 3.0028V
2000V	3 min.	1998 to 2002V	1.9973 to 2.0027V
1000V	3 min.	998 to 1002V	0.9974 to 1.0026V
500V	3 min.	498 to 502V	0.49745 to 0.50255V

*Maximum 3000V output with Filter 1 enabled.

4.5.2 DC current accuracy

The DC current accuracy test measures the accuracy of the output current limit and the mA (current) display.

1. Using the ohms function of the multimeter, measure and record the value of the 4.99kΩ resistor.
2. With the power off, connect the 4.99kΩ resistor, the 1MΩ load resistor, and the multimeter to the Model 248 HIGH VOLTAGE output connector, as shown in Figure 4-2. Note that the multimeter is connected across the 4.99kΩ resistor. Set the rear panel polarity switch to the POS position.

WARNING

For safety purposes, the resistors MUST be mounted within a safety shield connected to safety earth ground using #18AWG or larger wire. Be sure to connect the 4.99kΩ resistor to the low (chassis side) of the Model 248 output. Otherwise, the multimeter will be floated 5kV above earth ground, which could result in instrument damage or risk of electric shock.

3. Turn on the power, and recall the Model 248 default conditions. (Press RCL, 0, and then ENTER.)
4. Select the multimeter DCV function, and enable autoranging.
5. With the high voltage off, allow the multimeter reading to settle and then enable REL to null any residual offset voltage.
6. Set the Model 248 output voltage to 5000V, and set the current limit to 5mA. Turn the high voltage on.
7. Note the DMM reading, and then calculate the current as follows: I = V/R, where V is the multimeter voltage reading, and R is the actual value of the 4.99kΩ resistor measured in step 1.
8. Verify that the current computed in step 7 is within ±(0.01% + 2.5µA) of the programmed current limit value. Also, make sure that the front panel mA display reading is within ±2µA of the actual current value.
9. Repeat steps 6 through 8 for the remaining currents listed in Table 4-3. For each value:
   - Program the current limit to the correct value.
   - Measure and record the multimeter voltage reading.
   - Compute the current from the voltage and resistance.
   - Verify the computed and display current values are within required limits.
10. Turn off the high voltage, allow the voltage to discharge, and then set the polarity switch to NEG. Repeat steps 6 through 9 for negative output polarity.
11. Enable Filter 1, and then repeat the entire procedure with a 3000V output voltage.

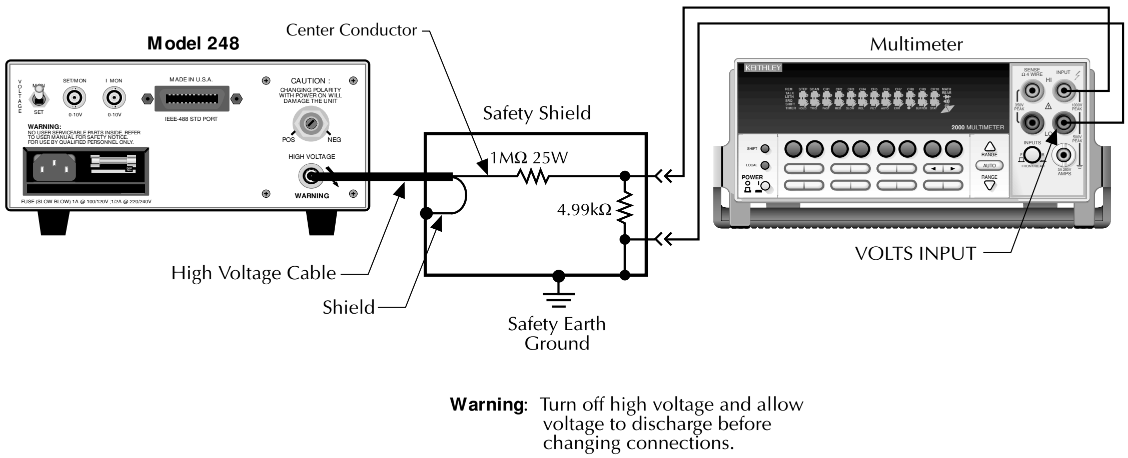


Figure 4-2
Connections for DC current accuracy tests

Table 4-3
DC current accuracy summary

Current limit setting	Multimeter voltage[1]	Calculated current[2]	Allowable current range[3]
500µA	________ V	________ µA	________ to ________ µA
1mA	________ V	________ mA	________ to ________ mA
1.5mA	________ V	________ mA	________ to ________ mA
2mA	________ V	________ mA	________ to ________ mA
2.5mA	________ V	________ mA	________ to ________ mA
3mA	________ V	________ mA	________ to ________ mA
3.5mA	________ V	________ mA	________ to ________ mA
4mA	________ V	________ mA	________ to ________ mA
4.5mA	________ V	________ mA	________ to ________ mA
5mA	________ V	________ mA	________ to ________ mA

[1] Voltage across 4.99kΩ resistor measured by multimeter.
[2] Calculated as follows: I = V/R, where V= multimeter voltage reading and R= measured resistor value.
[3] Limits calculated as follows: I ± [(0.01% × I) + 2.5µA], where I = calculated current.

4.5.3 Load regulation

The load regulation test measures the load regulation of the Model 248 output voltage.

1. With the power off, connect the Model 248 to the 1MΩ load resistor and high voltage divider using the SHV "T" connector (see Figure 4-3.) Connect the multimeter to the 10V output tap of the divider.

WARNING

The 1MΩ load resistor must be mounted within a metal shield to prevent the risk of electric shock. The shield and divider chassis must be connected to safety earth ground using #18AWG or larger wire.

2. Select the multimeter DCV function, and enable autoranging.
3. Set the rear panel polarity switch to the POS position.
4. Turn on the power, and recall the Model 248 default setup by pressing RCL, 0, and then ENTER.
5. Set the Model 248 output voltage to 5000V, and then turn on the high voltage output.
6. Note and record the multimeter voltage reading.
7. Turn off the high voltage, and allow the voltage to discharge completely.

WARNING

Turn off the high voltage and allow the voltage to fully discharge before changing connections.

8. Disconnect the 1MΩ load resistor.
9. Turn on the high voltage, and again note and record the multimeter voltage reading. Turn off the high voltage and allow the voltage to discharge.
10. Verify that the voltage reading obtained in step 9 is within 2.5mV of the voltage measurement taken in step 6.
11. Set the rear panel polarity switch to the NEG position, and then repeat steps 5 through 10 for negative output polarity.
12. Enable Filter 1, and then repeat steps 5 through 11 with an output voltage of 3000V DC.

4.5.4 Output voltage ripple

The output voltage ripple test measures the output ripple voltage of the Model 248.

1. With the power off, connect the Model 248 to the AC network, 1MΩ load, and multimeter, as shown in Figure 4-4.

WARNING

The AC network MUST be enclosed in a metal shield, which MUST be connected to safety earth ground using #18AWG or larger wire. Be sure to connect the multimeter to the low-voltage side of the AC network.

2. Turn on the Model 248 power, and recall the default settings by pressing RCL, 0, and then ENTER.
3. Select the multimeter ACV function and enable autoranging. Be sure that the TRMS measurement mode is enabled.
4. Set the Model 248 output voltage to 500V, and turn on the high-voltage output.
5. Verify that the multimeter AC voltage reading is <100mV RMS.
6. Repeat steps 4 and 5 at 500V increments (1000V, 1500V, ... 4500V, 5000V). In each case, verify that the ripple voltage is <100mV RMS.
7. Enable Filter 1 and then repeat steps 4 through 6 for voltages up to 3000V DC. With Filter 1 enabled, all ripple voltage measurements should be <3.5mV RMS.

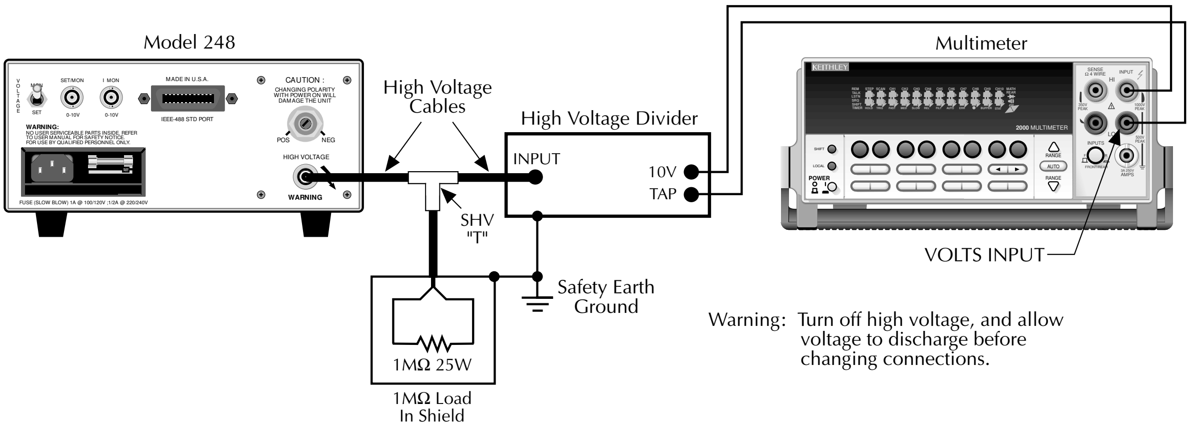


Figure 4-3
Connections for load regulation tests

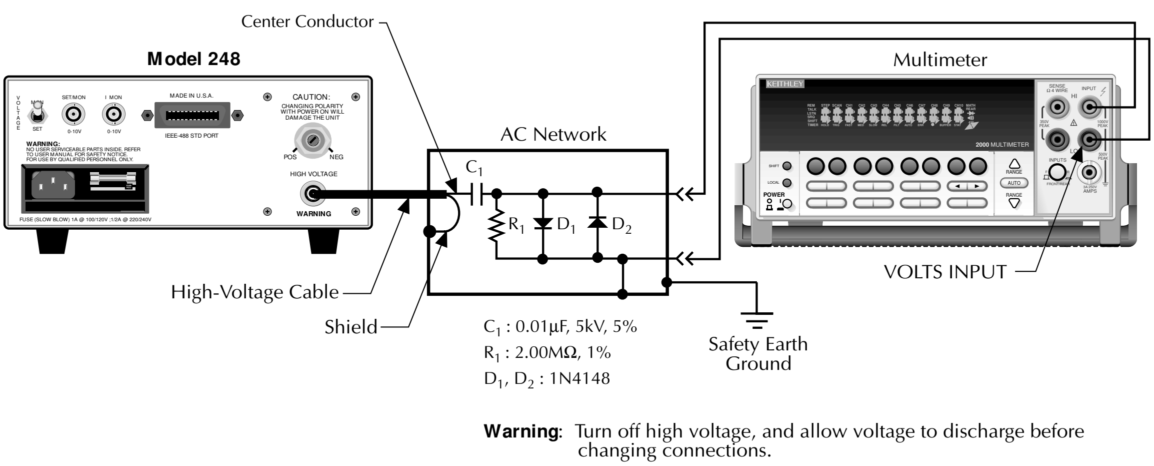


Figure 4-4
Connections for output voltage ripple tests

5

Servicing

5.1 Introduction

This section contains information on servicing the Model 248 and includes troubleshooting and circuit descriptions.

WARNING

The information in this section is intended for use by qualified service personnel only. Do not attempt to service the unit unless you are qualified to do so. Some procedures may expose you to high voltages. Always use extreme caution when working with high voltages. Be sure that the high voltage is off and completely discharged before connecting or disconnecting cables.

5.2 Troubleshooting

5.2.1 Line power

Always make certain that the power entry module is set for the correct line voltage and that the correct fuse is installed. The selected line voltage can be seen through the window on the power entry module. Verify that the line cord is plugged completely into the power entry module and that the front panel power switch is on.

5.2.2 Power-on reset

If the instrument turns on with unusual combinations of LEDs on, garbled displays, or is unresponsive to the keyboard; the memory contents may have been corrupted, causing the instrument to lock up. To remedy the situation, turn the unit off and hold down the CLR key while turning the power back on. Doing so causes the unit to initialize the memory and load the default setup.

5.2.3 Stuck keys

If the center display is filled with a particular number (such as 4444) or one particular message (such as Err2), and the keyboard is unresponsive, check to see if a key is stuck. If so, gently tap the stuck key back to the center of its hole to free it.

5.2.4 Output problems

Table 5-1 contains a list of possible output problems, a designation of the circuit that could be causing the output problem, and the generic part number needed for the repair of the indicated circuit.

Table 5-1
Output problems and repair information

Problem	**Circuit designation (possible cause)**	**Generic part number**
Output will not reach 200V.	Q203	MTP 20P06
Output will not reach 500V.	Q201, Q202	IRF 532
Output will not reach full voltage.	U205	LT 1085

5.2.5 No high voltage

If the 248 does not enable the high voltage, check to make sure that the HIGH VOLTAGE LED is on. If the HIGH VOLTAGE LED is OFF, check the following:

1. Make certain that you hold down the high voltage key for at least one-half second. This key requires a fairly long keypress to avoid turning on the high voltage accidentally.
2. Check the voltage limit and current trip levels to verify that they are sufficiently high for the expected output values.
3. If the HIGH VOLTAGE LED is ON, but the output voltage is zero or lower than expected, check the following:
   A. Check to see if the LIMIT LED is on. If so, the current limit value could be too low, or the load could be drawing excessive current.
   B. Make sure the voltage limit is as large or larger than the desired output voltage.
   C. Check the REAR LED. If it is on, the high voltage is being programmed by the analog voltage applied to the SET/MON input on the rear panel and not by the front panel. If so, make sure the rear panel VOLTAGE switch is in the desired position.

5.2.6 Repeated trips

Voltage Trips — This problem may occur if the load changes too rapidly, causing the voltage to overshoot. Try raising the voltage limit.

Current Trips — Disconnect the load, and note if the unit still trips. If the unit operates with no load, the load may be causing the problem. If the unit still trips with the load disconnected, the unit may be damaged. Contact the factory for further information.

Primary Trip — If repeated PTRPs occur, the power supply may be damaged. Contact the factory for further information.

5.2.7 Rear panel voltage set mode

If the output voltage is not correct, check the REAR LED and rear panel VOLTAGE Switch to verify the unit is in the SET mode. Also check that the voltage limit is higher than the desired voltage.

5.2.8 Front panel test

Hold down the ENTER key while turning on the unit to run the front panel test. After power is turned on, one segment of one numerical digit should be on. Press the up arrow key to step through all eight digit segments of the present digit and the following digit. This test verifies that all segment drivers are functional. When the up arrow key is pressed again, all segments and one of the single LEDs should be on. Repeatedly press the up arrow key to cycle through all single LEDs.

The keypad can then be tested by pressing each key and observing the key code on the display. The codes increase from top to bottom and left to right. After this test, turn the power off and then back on to restart the instrument.

5.3 Calibration

Calibration parameters are determined by a computer-aided calibration procedure after burn-in at the factory. These values are stored in the permanent memory of each unit. For this reason, no field calibration adjustments are necessary, and the unit should be returned to the factory for calibration.

5.4 Circuit description

5.4.1 Component locations

Most of the components are located on the main circuit board. The front panel and high voltage section are located on separate boards. In addition, the high-voltage board is covered with an acrylic coating and enclosed in a protective shield.

5.4.2 Voltage control

Since the high-voltage output is transformer coupled, only the magnitude of the voltage can be set by the primary side control circuitry. The high-voltage output polarity is controlled by a multi-pole switch. However, the sensed voltage and current depend on polarity and must be converted into a unipolar signal before they can be used to control the output voltage. To minimize the effects of noise, the sensed voltage and current are converted into a -8.26 to +8.26V range voltage (-8.26V corresponding to 0V out, +8.26V to full-scale). This conversion range allows the 13-bit DAC to cover a ±10V range with a relatively large resolution of 2.5mV per LSB.

The sensed voltage, V SENSE (coming from a resistive divider in the high voltage section), is buffered by a high-input impedance differential amplifier made up of U109A, U109B, and U101D, providing a 0 to +8.26V signal. The polarity is controlled (for positive or negative output voltages) with a programmable low-offset inverter (U102, U104A, and U104B) and then scaled to ±8.26V. The voltage is then compared to the programmed voltage by U101C. This signal is then frequency compensated (U108, U101A, and related resistors and capacitors) to provide an error voltage, V ERR. D104 and D107 prevent the large capacitors in the frequency compensation circuitry from saturating U108.

The sensed current is first amplified by U105 where the 0–250mV signal range is increased to 0 to +8.26V. The polarity is set by the programmable inverter made up of U104C, U104D, and U106, and the signal is scaled to ±8.26V by U107C. The signal is then compared and frequency compensated at U107B to provide I ERR.

D102 acts as a crossover between the two error signals to determine which signal sets V DRIVE, the control for the output voltage. If I ERR is higher than V ERR (voltage control mode), then V ERR controls V DRIVE. However, if I ERR is lower (supply is in current limit), it pulls down V DRIVE (through D102) to the appropriate level, since V ERR is isolated by R110.

Diodes D105 and D106 together with U107D act to keep op amps U108 and U107B respectively out of saturation during large load changes, thus improving transient response.

U613D and related components act as a soft-start circuit to minimize component stress when the high voltage is first turned on. When the high voltage is off, transistor U613D is turned on, holding V DRIVE low. After the high voltage is turned on, the processor turns off the transistor, allowing C108 to charge through R121. This charging action slows the initial rise of V DRIVE to the RC time constant until the collector voltage is above the controlling error signal (V ERR or I ERR). The soft-start circuit is then decoupled from the circuit by D103.

5.4.3 Pre-regulator and high-frequency inverter

High voltage is generated by a high-frequency DC-to-DC converter. This converter operates by driving the common tap of a step-up transformer, used as an inverter, from 0 to 35 volts DC. Thus, high voltage is generated through transformation and voltage multiplication. Control is achieved by regulating the common tap.

Pre-regulator

The common voltage is generated by a combination step-down pre-regulator followed by a programmable linear regulator. Q203, D203, L201, and C203 form the step-down regulator, and U205 is the linear regulator.

U206, an LM111 comparator, senses the voltage across U205. If the voltage is less than 2.5V (determined by D204, a 2.5V reference), the comparator output goes negative. This negative signal turns on Q203, allowing current to flow through L201 and C203, raising the voltage at the input of U205. Once the voltage across U205 is greater than 2.5V (plus a small amount of hysteresis determined by R219 and C205), U206 shuts off Q203. Current continues to flow through L201 during the off time because of its inductance. This current causes the voltage at pin 2 of Q203 to flyback negatively and be clamped by D203. The voltage across U205 will now decay until it is less than 2.5V, at which point the cycle begins again.

U205, an LT1085, is a low-dropout adjustable regulator, which filters the output of the step-down section. U207 increases the V DRIVE signal range from 0-12V to 0-33V, which programs the common tap of the step-up high-voltage transformer.

Inverter

U201 is an LM555 timer configured as a stable multivibrator at a frequency of 40 kHz with duty cycle of approximately 60%. U202 and U203 convert this signal into two phases of 20kHz at a 30% duty cycle. U204 (SN75372) is a high-current MOSFET driver for the FETs (Q201,Q202) that drive the high voltage step-up transformer. D201 and D202 clamp excessive inductive flyback voltage.

If the primary current exceeds 5.3A, R212–R215 and U301C sense the primary side current and shut off the drive to the inverter (and thus the high voltage). They do so by activating the HV OFF line, which latches the high voltage off until the processor releases it. The high voltage can also be turned off by voltage or current trips and by the processor.

5.4.4 Limits and trips

U301 is a quad comparator that compares the scaled output voltage and current to both the limit and trip values, which are set by the processor and D/A. If a trip value is exceeded, the high voltage is shut off through the HV OFF signal, and the change of status is reported to the processor. If a limit is exceeded, only the change of status is reported. The processor can also set the HV OFF line via the SHUTDOWN line.

U306 is a one-shot circuit used as a watch dog timer. Unless the microprocessor resets the timer every 10ms, the one-shot times out, turning off the high voltage and forcing a system reset.

5.4.5 A/Ds and D/As

U410 is a 12-bit digital-to-analog converter that is loaded four bits at a time from the processor. Its output current is converted to a voltage by U402B to provide a 0 to -10.00V DC referenced from LH0070 (U406), a precision reference. U407A, U407B, and U405 form a programmable low-offset inverter. After scaling, the output covers a range of -10.24 to +10.24V DC with 13 bits and 2.5mV of resolution. These outputs are multiplexed to six sample and hold circuits that provide control voltages and outputs. Each sample and hold is refreshed every 12ms.

U402A and U404 form an integrating, successive-approximation, analog-to-digital converter. U409 determines the input to be sampled and integrates it through R404 and C401. A successive-approximation, 13-bit, analog-to-digital conversion is then performed using the D/A converter and comparator U404. The conversion process takes about 100µs.

5.4.6 Microprocessor control

The microprocessor, U501 (a Z80), is clocked at 4MHz by X501. U502, an 8K ROM, contains the firmware and calibration constants. The 2K static RAM, U503, is backed by a lithium battery, BT501. A power-down circuit protects the RAM contents by disabling the chip-select line with Q501 if a reset is asserted. The battery has a typical useful life of five to ten years and does not normally require field replacement.

U504 and U505 generate chip selects for the various input and output ports. U506 and U512 are input ports for status information, rear panel switches, and the HV ON/OFF switch on the front panel.

U509 and related components form the power-on reset circuit. During power-on, this IC asserts a reset signal for about 250ms to allow the supply voltages to stabilize. If the +5V power supply drops below 4.5V (determined by the +10.00V reference), it asserts a reset signal until the voltage recovers and a reset cycle has occurred. If the watch dog timer is not updated every 10ms, it triggers U511, which also forces a reset. During a reset, the high voltage is turned off, the processor is reset, and RAM is disabled.

5.4.7 GPIB and front panel interface

GPIB

GPIB (IEEE-488) interfacing is provided by the TMS9914A controller, U601. U602 and U603 are buffers to the GPIB connector, which is connected to J602. U601 is programmed to interrupt the processor whenever the Model 248 is programmed over the bus.

Front panel interface

The front panel has a six-phase, multiplexed LED display and keyboard. U604 is a data bus latch for U605, a high-current driver that provides the strobe signals to the front panel. Each strobe selects two digits and two or three LEDs to be refreshed with only one strobe active at a time. U606 and U609 are pull-down lines for the digits with 390Ω current-limiting resistors (N601 and N602). The individual LEDs are pulled down separately by U613A-U613C with 12Ω current-limiting resistors (R602-R604). These circuits are separated from the digit pulldowns because the LEDs require much more current than the high-efficiency, seven-segment displays. Strobes 2, 3, and 4 are also fed to the keypad matrix, which is read by U612, an input latch.

U610, a divider chip, divides the 4MHz system clock by 4096 to generate a 977Hz interrupt signal. This signal interrupts the processor on a real-time basis to synchronize updating the display, analog voltages, and instrument status.

5.4.8 Low voltage power supplies

Line power enters the power entry module through a fuse and an RFI filter. Both the hot and neutral leads of the power line are switched. The voltage then goes to the line voltage selector, which selects among four different power transformer primary taps: 100,120, 220, 240V AC, 50 or 60 Hz.

The power transformer has three secondaries: 63V AC, 32V AC, and 15V AC, all center tapped. The 15V tap is rectified by D703 and D704, and filtered by C706 to generate +8V DC unregulated. The +8V supply is regulated by U704 to +5V DC for the processor, digital logic, and LED display. The 32V tap is full-wave rectified by U701 and filtered by C702 and C705 to provide ±18V DC. These supplies are regulated to ±15V DC by U702 and U703 to generate voltages for the analog circuitry.

The 63V tap, rectified by D701 and D702 and filtered by C701, provides +35V DC at 1A for the high voltage section pre-regulator. U705 provides a regulated +33V DC for the control circuits in the pre-regulator.

5.4.9 Front panel

The front panel consists of twelve 7-segment, high-efficiency displays, a ±1 display, 13 LEDs, a keypad, and the high voltage on/off switch.

The displays are multiplexed by six strobe lines. During each strobe pulse, two of the twelve displays are on. In addition, up to two (of a maximum of three) LEDs are on to indicate the instrument status and polarity. The ±1 display is driven in the same manner as the LEDs, but it uses larger current-limiting resistors (R1 and R2, 390Ω), since it is far more efficient than the ordinary LEDs. Finally, strobes 2, 3, and 4 are routed to the keypad matrix, allowing one-third of the keys to be read during each strobe cycle.

The HIGH VOLTAGE ON/OFF switch is separate from the keypad matrix. Its signals are fed directly back to one of the processor's input ports.

5.4.10 High voltage section

WARNING

The high voltage section is covered for protection against electric shock. Do not attempt to operate the unit with the cover removed.

The Model 248 high voltage section uses a voltage quadrupler made up of C1, C2, C3, C4, D1, D2, D3, and D4. Poles A and B of switch SW1 change the polarity of the high voltage output, while pole C reports the polarity to the processor. The voltage sense divider circuit is made up of resistors (R4-R8), and R9 is the current sense resistor. Finally C3, C4, and R1-R3 make up an output filter to reduce switching noise.

5.5 Disassembly

Use the following procedures to disassemble the Model 248 for troubleshooting and repair. In general, disassembly should be performed in the order presented.

Figure 5-1 shows an exploded view of the unit.

WARNING

Disconnect the line cord and all other cables from the unit before disassembly.

5.5.1 Cover removal

1. Remove the four screws that secure the cover to the chassis near the front panel.
2. Remove the two screws that secure the case cover to the chassis near the rear panel.
3. Carefully slide the cover off the chassis towards the rear of the unit.

5.5.2 Front panel and display board removal

1. Unplug the ribbon cable connected to the main circuit board.
2. Remove the four screws that secure the front panel to the chassis and the screws that attach the main circuit board to the front panel.
3. Turn the unit upside down.
4. While holding the power switch pushrod, carefully pull the front panel away from the chassis and then remove the pushrod from the power switch.
5. To remove the display board, unsolder the wires going to the HIGH VOLTAGE switch, remove the display board screws, and then separate the display board and front panel.

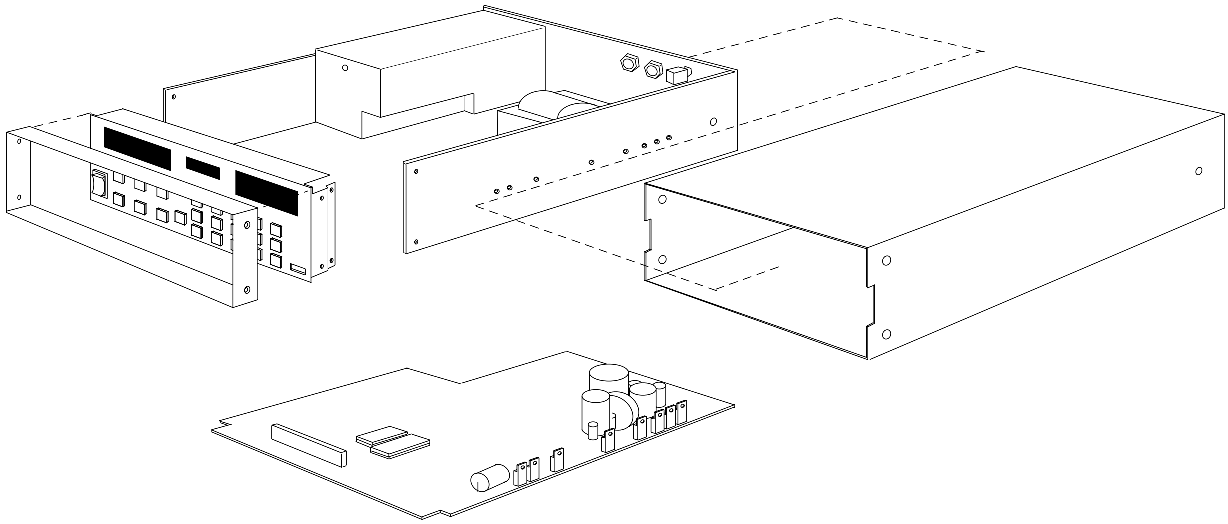


Figure 5-1
Model 248 exploded view

5.5.3 Main circuit board removal

1. Note and record the positions and colors of all wires connected to the main circuit board, and then carefully unsolder the wires.
2. Unplug the IEEE-488 interface ribbon cable.
3. Remove the screws and nuts that secure the regulators to the slide chassis.
4. Remove the screws that secure the main circuit board to the main chassis and high-voltage module.
5. Carefully remove the main circuit board from the chassis.

5.5.4 High-voltage module removal

To remove the high-voltage module, remove the screws that secure the module to the chassis and then remove the module.

5.5.5 Miscellaneous parts removal

To remove the power transformer and rear panel parts, remove the attachment screws or nuts and then remove the parts from the chassis.

5.5.6 Reassembly

In general, the instrument can be reassembled by reversing the disassembly process. When reassembling the unit, be sure:

- To properly secure all nuts and screws.
- That all wires are resoldered correctly.
- The display board and IEEE-488 interface ribbon cables are plugged in.
- The case cover is properly installed and secured with the attachment screws.

6
Replaceable Parts

6.1 Introduction

This section contains replacement parts information for the Model 248.

6.2 Parts lists

See Table 5-1 for part number repair information. For more information on replaceable parts, call the Repair Department at 1-800-552-1115.

6.3 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:

- Instrument model number (Model 248)
- Instrument serial number
- Part description
- Component designation (if applicable)
- Part number

6.4 Factory service

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

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

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.

KEITHLEY

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

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