Model 2500
Dual Photodiode Meter
Service Manual

Contains Calibrating and Servicing Information

KEITHLEY

WARRANTY

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

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

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

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

LIMITATION OF WARRANTY

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

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Model 2500 Dual Photodiode Meter
Service Manual

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Manual Print History

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

Revision A (Document Number 2500-902-01) ..... August 2000

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

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Performance Verification

Introduction

Use the procedures in this section to verify that Model 2500 Dual Photodiode Meter accuracy is within the limits stated in the instrument's one-year accuracy specifications. Perform these verification procedures:

- Upon receipt of the instrument make sure it was not damaged during shipment.
- Verify that the unit meets factory specifications.
- Determine if calibration is required.
- Follow calibration to make sure it was performed properly.

WARNING **The information in this section is intended for qualified service personnel only. Do not attempt these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages which could cause personal injury or death if contacted. Use standard safety precautions when working with hazardous voltages.**

NOTE *If the instrument is still under warranty and its performance is outside specified limits, contact your Keithley representative, or the factory, to determine the correct course of action.*

Verification test requirements

Be sure to perform the verification tests:

- Under the proper environmental conditions.
- After the specified warm-up period.
- Using the correct line voltage.
- Using the proper test equipment.
- Using the specified output signals and reading limits.

Environmental conditions

Conduct performance verification procedures in a test environment with:

- An ambient temperature of 65-82°F (18-28°C).
- A relative humidity of less than 70% unless otherwise noted.

Warm-up period

Allow the Model 2500 to warm up for at least one hour before conducting the verification procedures.

If the instrument has been subjected to temperature extremes (those outside the ranges stated above), allow additional time for the instrument's internal temperature to stabilize. Typically, allow one extra hour to stabilize a unit that is 50°F (10°C) outside the specified temperature range.

Allow the test equipment to warm up for the minimum time specified by the manufacturer.

Line power

The Model 2500 requires a line voltage of 100V / 120V / 200V / 240V (depending on rear panel line frequency setting) and a line frequency of 50 or 60Hz. Verification tests must be performed within this range. Make sure the line voltage setting seen through the small window in the rear panel power module is at the required setting. If not, change the setting as covered in Section 3.

Recommended test equipment

Table 1-1 summarizes recommended verification equipment and pertinent specifications. You can use alternate equipment as long as that equipment has specifications at least as good as those listed in Table 1-1. Keep in mind, however, that test equipment uncertainty will add to the uncertainty of each measurement. Generally, test equipment uncertainty should be at least four times better than corresponding Model 2500 specifications.

NOTE *The Calibrator/Source listed in Table 1-1 does not quite meet the recommended four times better uncertainty for 19µA to 19mA output values. Factory calibration uses a transfer standard technique that yields uncertainties better that 4:1 for all calibration points.*

Table 1-1
Recommended verification equipment

Description	Manufacturer/Model	Specifications			Uncertainty Ratio[4]
Calibrator/Source	Keithley 263	DC Current[1]	1.9nA:	±0.068%	15:1
			19nA:	±0.068%	6:1
			190nA:	±0.04%	7.6:1
			1.9µA:	±0.03%	6.75:1
			19µA:	±0.03%	3.4:1
			190µA:	±0.03%	3.4:1
			1.9mA:	±0.03%	3.4:1
			19mA[2]:	±0.04%	2.6:1
Digital Multimeter	Keithley 2001	DC Voltage[3]	20V:	±22ppm	45:1
			200V:	±30ppm	33:1

[1]90-day accuracy specifications at specified output for passive V/R amps mode except as noted.
[2]90-day specifications at 19mA output for active amps mode.
[3]90-day full-range accuracy specifications.
[4]Ratio between test equipment uncertainty and Model 2500 uncertainty.

Verification limits

The verification limits listed in this section have been calculated using only the Model 2500 one-year accuracy specifications, and they do not include test equipment uncertainty. If a particular measurement falls outside the allowable range, recalculate new limits based on Model 2500 specifications and corresponding test equipment specifications.

Example limits calculation

As an example of how verification limits are calculated, assume you are testing the 2mA range with a 1.9mA input current. Using the Model 2500 one-year accuracy specification of ±(0.1% of reading + 50nA offset), the calculated reading limits are:

Limits = 1.9mA ± [(1.9mA × 0.1%) + 2µA]
Limits = 1.9mA ± (1.9µA + 2µA)
Limits = 1.9mA ± 3.9µA
Limits = 1.8961mA to 1.9039mA

Restoring factory defaults

Before performing the verification procedures, restore the instrument to its factory front panel (BENCH) defaults as follows:

1. Press the MENU key. The instrument will display the following prompt:
   MAIN MENU
   SAVESETUP COMMUNICATION CAL 4
2. Select SAVESETUP and then press ENTER. The unit then displays:
   SAVESETUP MENU
   SAVE RESTORE POWERON RESET
3. Select RESET and then press ENTER. The unit displays:
   RESET ORIGINAL DFLTS
   BENCH GPIB
4. Select BENCH and then press ENTER to restore BENCH defaults.

Performing the verification test procedures

Test summary

- Current measurement accuracy
- Voltage bias accuracy

If the Model 2500 is not within specifications and not under warranty, see the calibration procedures in Section 2 for information on calibrating the unit.

Test considerations

When performing the verification procedures:

- Be sure to restore factory front panel defaults as previously outlined.
- Make sure that the test equipment is fully warmed up and properly connected to the correct Model 2500 terminals as required.
- Allow signals to settle before making a measurement.
- Do not connect test equipment to the Model 2500 through a scanner, multiplexer, or other switching equipment.

WARNING **The maximum common-mode voltage (voltage between LO and chassis ground) is 200V DC. Exceeding this value may cause a shock hazard.**

CAUTION **Maximum signal on OUTPUT connectors is 100V @ 20mA DC. Maximum signal on INPUT connectors is 20mA. Exceeding these values may result in damage to the instrument.**

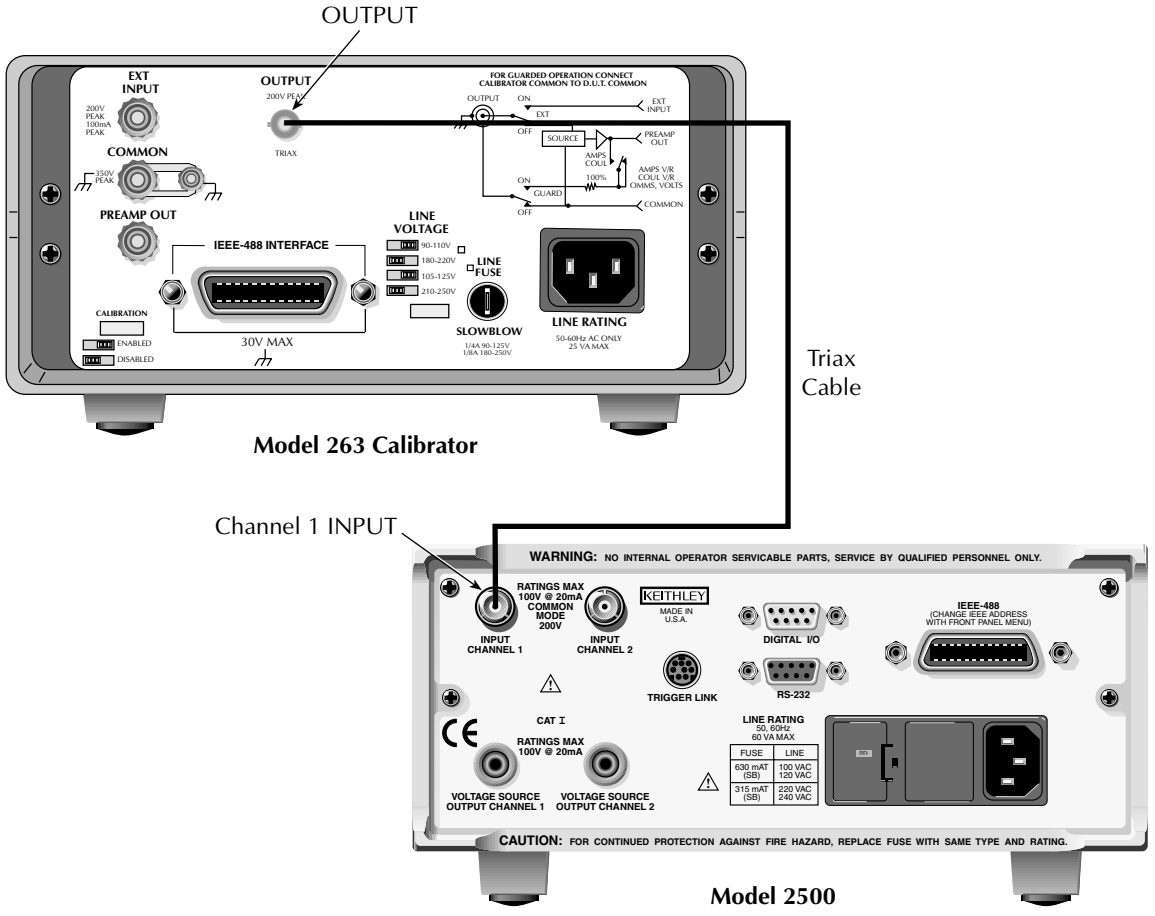
Current measurement accuracy

Follow the steps below to verify that Model 2500 current measurement accuracy is within specified limits. This test involves applying currents from a calibrator and verifying that Model 2500 current readings are within required limits.

1. With the power off, connect the calibrator to the INPUT CHANNEL 1 triax jack, as shown in Figure 1-2.
2. Turn on the Model 2500 and calibrator, and allow them to warm up for at least one hour.
3. Restore front panel (BENCH) defaults as outlined in “Restoring factory defaults.”

4. Press the MSR1 key, then select the Model 2500 2nA range on channel 1 with the RANGE ▼ key.
5. Select the calibrator passive amps function, and choose the 2nA range.
6. Set the calibrator output to 1.90000nA, and turn the output on.

Figure 1-1
Connections for channel 1 current verification tests



7. Verify that the Model 2500 current reading is within the limits for the 2nA range shown in Table 1-2.
8. Repeat steps 4 through 7 for the 20nA through 20mA ranges. (Use the calibrator active amps mode for the 20mA range.)
9. Repeat steps 4 through 8 for negative input currents of the same magnitude.

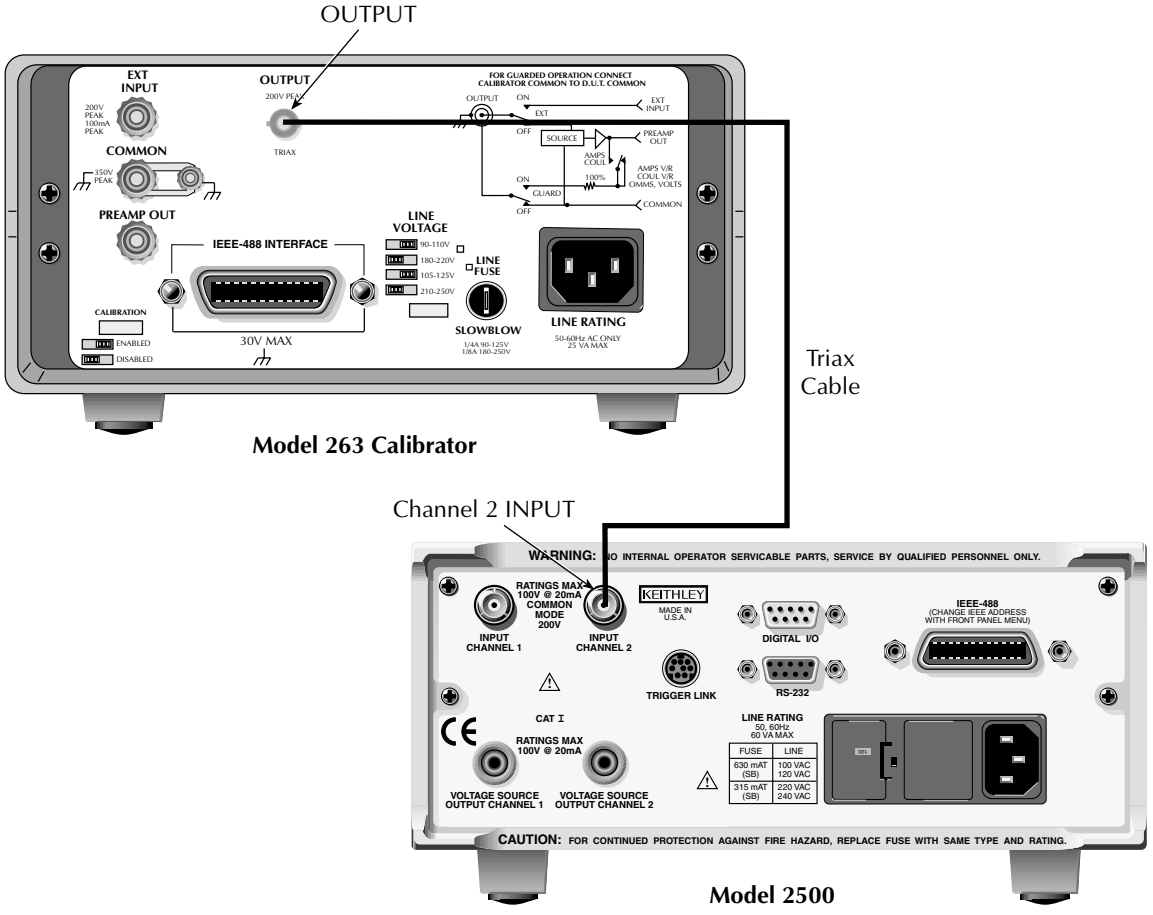
Table 1-2
Current measurement verification limits

Model 2500 range	Calibrator current	Reading limits* 1 year, 65°F to 82°F (18°C to 28°C)
2nA	1.90000nA	1.87900 to 1.92100nA
20nA	19.0000nA	18.9220 to 19.0780nA
200nA	190.000nA	189.230 to 190.770nA
2µA	1.90000µA	1.89600 to 1.90400µA
20µA	19.0000µA	18.9610 to 19.0390µA
200µA	190.000µA	189.790 to 190.210µA
2mA	1.90000mA	1.89610 to 1.90390mA
20mA	19.0000mA	18.9790 to 19.0210mA

*Limits do not include calibrator uncertainty.

10. After verifying all ranges on channel 1, repeat the entire procedure for channel 2. Connect the calibrator to the INPUT CHANNEL 2 jack, and select channel 2 by pressing MSR2. (See Figure 1-2 for connections.)

Figure 1-2
Connections for channel 2 current verification tests

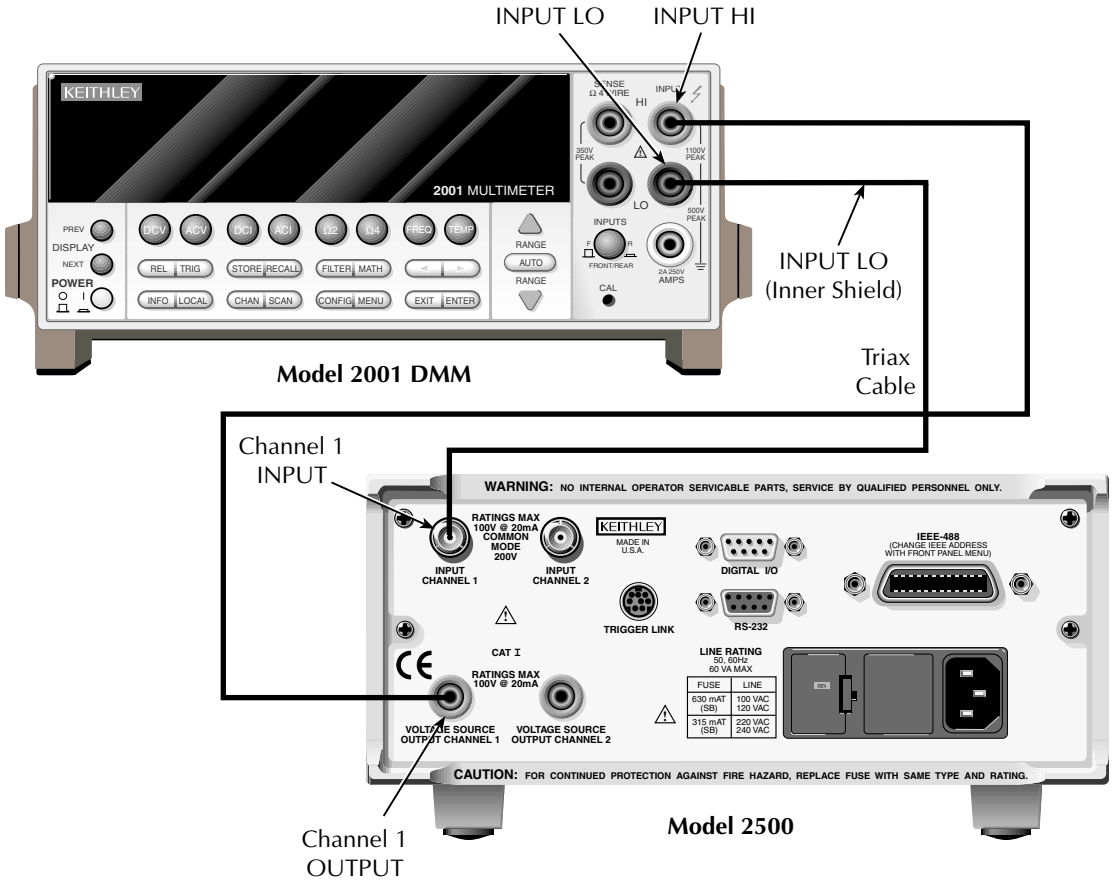


Voltage bias accuracy

Follow the steps below to verify that Model 2500 bias voltage accuracy is within specified limits. This test involves setting the bias voltage to specific values and measuring the voltages with a DMM.

1. With the power off, connect the digital multimeter to the Model 2500 channel 1 INPUT and OUTPUT jacks, as shown in Figure 1-3. (Connect DMM INPUT HI to the VOLTAGE SOURCE OUTPUT CHANNEL 1 jack, and connect DMM INPUT LO to the inner ring (LO) of the INPUT CHANNEL 1 jack.)
2. Turn on the Model 2500 and DMM, and allow them to warm up for at least one hour.
3. Restore BENCH defaults as covered in "Restoring factory defaults."
4. Select the multimeter DC volts measuring function, and choose auto-range.
5. Press the SCR1 key, then select the Model 2500 10V bias range on channel 1 with the RANGE ▼ key.
6. Set the channel 1 source voltage to +10.000V as follows:
   - Press the SRC1 key. Note that the EDIT annunciator turns on, and a digit blinks in the `Src1:` display field to indicate the unit is in the edit mode.
   - Set the source value in one of two ways: (1) key in the value using the numeric keys, or (2) set the value using the EDIT keys. Use EDIT ◀ and ▶ to place the cursor on the digit to be changed, and use EDIT ▲ and ▼ to increment or decrement the value.
7. Press the OUTPUT key to turn on the output.

Figure 1-3
Connections for channel 1 bias voltage verification tests



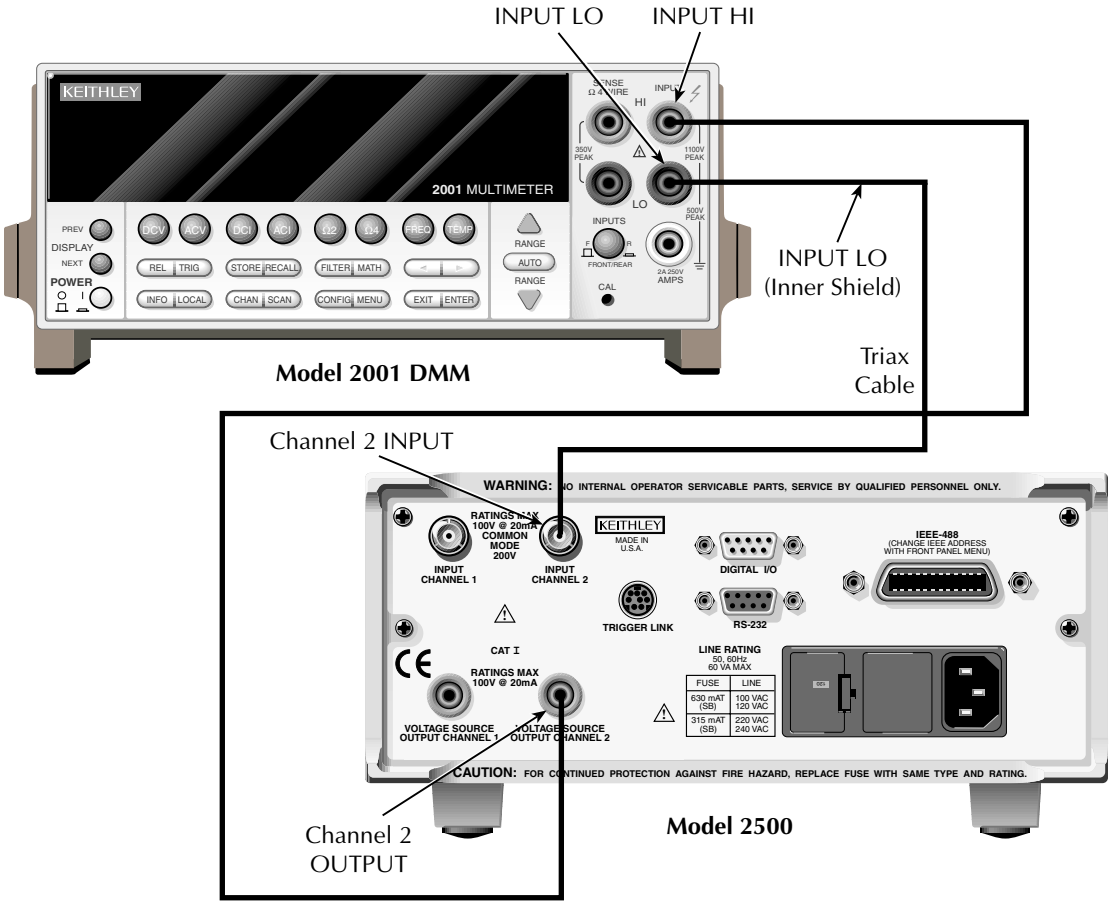
8. Verify the bias voltage output is within the limits for the 10V range shown in Table 1-3.
9. Repeats steps 6 and 8 for an output voltage of -10.000V.
10. Press the OUTPUT key to turn off the output.
11. Repeat steps 5 through 10 for the 100V bias voltage range with both +100.00V and -100.00V output voltages.

Table 1-3
Bias voltage accuracy limits

Model 2500 bias range	Bias voltage	Bias voltage limits 1 year, 65°F to 82°F (18°C to 28°C)
10V	10.000V	9.98 to 10.02V
100V	100.00V	99.65 to 100.35V

12. Repeat the entire procedure for channel 2 (Press SRC2 to select channel 2, and make your connections to the channel 2 INPUT and OUTPUT jacks. See Figure 1-4).

Figure 1-4
Connections for channel 2 bias voltage verification tests



2
Calibration

Introduction

Use the procedures in this section to calibrate the Model 2500 Dual Photodiode Meter. These procedures require accurate test equipment to supply precise currents and measure accurate DC voltages. Calibration can be performed either from the front panel or by sending SCPI calibration commands over the IEEE-488 bus or RS-232 port with the aid of a computer.

WARNING **The information in this section is intended for qualified service personnel only. Do not attempt these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages.**

Environmental conditions

Temperature and relative humidity

Conduct the calibration procedures at an ambient temperature of 65-82°F (18-28°C) with relative humidity of less than 70% unless otherwise noted.

Warm-up period

Allow the Model 2500 to warm up for at least one hour before performing calibration.

If the instrument has been subjected to temperature extremes (those outside the ranges stated above), allow additional time for the instrument's internal temperature to stabilize. Typically, allow one extra hour to stabilize a unit that is 50°F (10°C) outside the specified temperature range.

Allow the test equipment to warm up for the minimum time specified by the manufacturer.

Line power

The Model 2500 requires a line voltage of 100V / 120V / 200V / 240V (depending on line voltage setting) at line frequency of 50 or 60Hz. The instrument must be calibrated while operating from a line voltage within this range. Make sure the line voltage setting seen through the small window in the rear panel power module is at the required setting. If not, change the setting as covered in Section 3.

Calibration considerations

When performing the calibration procedures:

- Make sure the test equipment is properly warmed up and connected to the Model 2500 input or output terminals as required.
- Allow signals to settle before calibrating each point.
- Do not connect test equipment to the Model 2500 through a scanner or other switching equipment.
- If an error occurs during calibration, the Model 2500 will generate an appropriate error message. See Appendix B for more information.

WARNING **The maximum common-mode voltage (voltage between LO and chassis ground) is 200V DC. Exceeding this value may cause a shock hazard.**

CAUTION **Maximum signal on OUTPUT connectors is 100V @ 20mA DC. Maximum signal on INPUT connectors is 20mA. Exceeding these values may result in damage to the instrument.**

Calibration cycle

Perform calibration at least once a year to ensure the unit meets or exceeds its specifications.

Recommended calibration equipment

Table 2-1 lists the recommended equipment for the calibration procedures. You can use alternate equipment as long as that equipment has specifications at least as good as those listed in the table. For optimum calibration accuracy, test equipment specifications should be at least four times better than corresponding Model 2500 specifications.

NOTE *The Calibrator/Source listed in Table 2-1 does not quite meet the recommended four times better uncertainty for 19µA to 19mA output values. The Model 2500 may not meet factory calibration accuracy specifications on the 20µA to 20mA ranges unless further steps are taken to characterize the corresponding calibrator ranges using more accurate equipment. Factory calibration uses a transfer standard technique that yields uncertainties better than 4:1 for all calibration points.*

Table 2-1
Recommended calibration equipment

Description	Manufacturer/Model	Specifications			Uncertainty Ratio[4]
Calibrator/Source	Keithley 263	DC Current[1]	1.9nA:	±0.068%	15:1
			19nA:	±0.068%	6:1
			190nA:	±0.04%	7.6:1
			1.9µA:	±0.03%	6.75:1
			19µA:	±0.03%	3.4:1
			190µA:	±0.03%	3.4:1
			1.9mA:	±0.03%	3.4:1
			19mA[2]:	±0.04%	2.6:1
Digital Multimeter	Keithley 2001	DC Voltage[3]	20V:	±22ppm	45:1
			200V:	±30ppm	33:1

[1]90-day accuracy specifications at specified output for passive V/R amps mode except as noted.
[2]90-day specifications at 19mA output for active amps mode.
[3]90-day full-range accuracy specifications.
[4]Ratio between test equipment uncertainty and Model 2500 uncertainty.

Calibration menu

Table 2-2 summarizes the main calibration menu selections. To enter the calibration menu, press the MENU key, select CAL, then press ENTER. Use the EDIT keys to move the cursor and scroll through menu selections. Press ENTER to select a MENU item.

Table 2-2
Calibration menu

Menu selection	Description
UNLOCK	Unlock calibration using password (default: 002500).
EXECUTE	Execute calibration steps.
V-CAL	Voltage bias calibration.
CHAN-1	Channel 1 voltage bias calibration.
CHAN-2	Channel 2 voltage bias calibration.
I-CAL	Current measurement calibration.
CHAN-1	Channel 1 current calibration.
CHAN-2	Channel 2 current calibration.
OFFSET	Auto-zero input offset for both channels.
VIEW-DATES	View calibration dates.
SAVE	Save calibration constants.
LOCK	Lock out calibration.
CHANGE-PASSWORD	Change calibration password.

Unlocking calibration

Before performing calibration, you must first unlock calibration by entering or sending the calibration password as explained in the following paragraphs.

Unlocking calibration from the front panel

1. Press the MENU key, then choose CAL, and press ENTER. The instrument will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶
   ◀ SAVE LOCK CHANGE-PASSWORD
2. Select UNLOCK and then press ENTER. The instrument will display the following:
   PASSWORD:
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
3. Use the EDIT ▲ and ▼ keys to select the letter or number, and use the EDIT ◀ and ▶ arrow keys to choose the position. (Press ▼ for letters; ▲ for numbers.) Enter the present password on the display. (Front panel default: 002500.)
4. Once the correct password is displayed, press the ENTER key. You can then proceed with the calibration procedure.

Unlocking calibration by remote

To unlock calibration via remote, send the following command:

```
:CAL:PROT:CODE      '<password>'
```

For example, the following command uses the default password:

```
:CAL:PROT:CODE      'KI002500'
```

Changing the password

The default password (002500) may be changed from the front panel or via remote as discussed below.

Changing the password from the front panel

Follow these steps to change the password from the front panel:

1. Press the MENU key, then choose CAL, and press ENTER. The instrument will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶
   ◀ SAVE LOCK CHANGE-PASSWORD
2. Select UNLOCK then enter the password. (Default: 002500.)
3. Select CHANGE-PASSWORD and then press ENTER. The instrument will display the following:
   New Pwd: 002500
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
4. Using the EDIT keys, enter the new password on the display.
5. Once the desired password is displayed, press the ENTER key to store the new password.

Changing the password by remote

To change the calibration password by remote, first send the present password, and then send the new password. For example, the following command sequence changes the password from the 'KI002500' remote default to 'KI_CAL':

```
:CAL:PROT:CODE      'KI002500'
:CAL:PROT:CODE      'KI_CAL'
```

You can use any combination of letters and numbers up to a maximum of eight characters.

NOTE *If you change the first two characters of the password to something other than "KI", you will not be able to unlock calibration from the front panel.*

Resetting the calibration password

If you lose the calibration password, you can unlock calibration by shorting together the CAL pads which are located on the display board. Doing so will also reset the password to the factory default (002500, front panel; KI002500, remote).

See Section 5 for details on disassembling the unit to access the CAL pads. Refer to the display board component layout drawing at the end of Section 6 for the location of the CAL pads.

Viewing calibration dates and calibration count

When calibration is locked, only the UNLOCK and VIEW-DATES selections will be accessible in the calibration menu. To view calibration dates and calibration count at any time:

1. From normal display, press MENU, select CAL, and then press ENTER. The unit will display the following:

   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶

2. Select VIEW-DATES and then press ENTER. The Model 2500 will display the next and last calibration dates and the calibration count as in the following example:

   NEXT CAL: 04/15/2001
   Last cal: 04/15/2000 Count: 0001

Calibration errors

The Model 2500 checks for errors after each calibration step, minimizing the possibility that improper calibration may occur due to operator error.

Front panel error reporting

If an error is detected during comprehensive calibration, the instrument will display an appropriate error message (see Appendix B). The unit will then prompt you to repeat the calibration step that caused the error.

Remote error reporting

You can detect errors while in remote by testing the state of EAV (Error Available) bit (bit 2) in the status byte. (Use the *STB? query to request the status byte.) Query the instrument for the type of error by using the :SYST:ERR? query. The Model 2500 will respond with the error number and a text message describing the nature of the error. See Appendix B for details.

Aborting calibration steps

To abort a calibration step from the front panel, press the EXIT key. To abort a calibration step via remote, send the :ABORt command.

Front panel calibration

The front panel calibration procedure described below calibrates all functions. Note that each function and range is separately calibrated, and the procedure must be performed in the order shown.

Step 1. Prepare the Model 2500 for calibration

1. Turn on the Model 2500 and the calibration equipment, and allow them to warm up for at least one hour before performing calibration.
2. Press the MENU key, then choose CAL, and press ENTER. Select UNLOCK and then press ENTER. The instrument will display the following:

   PASSWORD:
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.

3. Use the EDIT ▲ and ▼ keys to select the letter or number, and use the ◀ and ▶ arrow keys to choose the position. (Press EDIT ▼ for letters; ▲ for numbers.) Enter the present password on the display. (Front panel default: 002500.)
4. Press ENTER to complete the process.
5. Press EXIT to return to normal display.

Table 2-3
Front panel calibration summary

Function[1]	Calibration step[2]	Test connections
OFFSET	INPUT offset voltage calibration	Channel 1 and channel 2 INPUT jacks left open (capped).
V-CAL	Voltage bias calibration	
CHAN-1	Channel 1 calibration	
	Positive full scale output	DMM to channel 1 OUTPUT and INPUT jacks (Figure 2-1)
	Zero output	DMM to channel 1 OUTPUT and INPUT jacks (Figure 2-1)
	Negative full scale output	DMM to channel 1 OUTPUT and INPUT jacks (Figure 2-1)
CHAN-2	Channel 2 calibration	
	Positive full scale output	DMM to channel 2 OUTPUT and INPUT jacks (Figure 2-2)
	Zero output	DMM to channel 2 OUTPUT and INPUT jacks (Figure 2-2)
	Negative full scale output	DMM to channel 2 OUTPUT and INPUT jacks (Figure 2-2)
I-CAL	Current calibration	
CHAN-1	Channel 1 calibration	
	Positive full scale input	Calibrator to channel 1 INPUT jack (Figure 2-3)
	Zero input	Calibrator to channel 1 INPUT jack (Figure 2-3)
	Negative full scale input	Calibrator to channel 1 INPUT jack (Figure 2-3)
CHAN-2	Channel 2 calibration	
	Positive full scale input	Calibrator to channel 2 INPUT jack (Figure 2-4)
	Zero input	Calibrator to channel 2 INPUT jack (Figure 2-4)
	Negative full scale input	Calibrator to channel 2 INPUT jack (Figure 2-4)

[1]CAL EXECUTION menu selections.
[2]Steps repeated separately for each range.

Step 2. Input offset voltage calibration

1. Install a triax shielding cap on both INPUT jacks.
2. Select OFFSET from the CAL EXECUTION menu, then press ENTER. The unit will display:
   CURRENT OFFSET CAL
   Input 0A then press ENTER
3. Press ENTER to complete input voltage calibration.

NOTE *This step calibrates offset voltage for both channels.*

Step 3. Channel 1 voltage source calibration

Follow the steps below to calibrate both channel 1 bias voltage ranges. Table 2-4 summarizes calibration ranges and voltages.

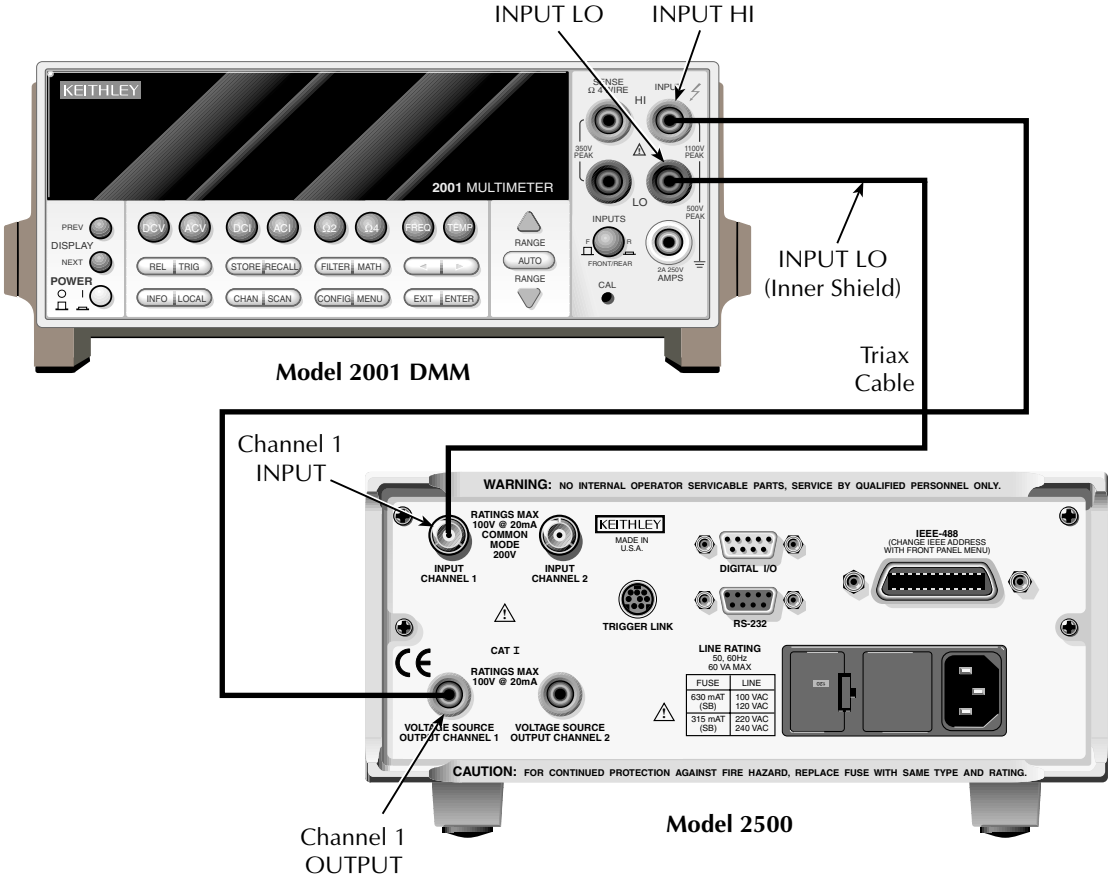
1. Connect the DMM to the Model 2500 channel 1 INPUT and OUTPUT jacks, as shown in Figure 2-1. (Connect DMM INPUT HI to the VOLTAGE SOURCE OUTPUT CHANNEL 1 jack; connect DMM INPUT LO to the inner shield of the INPUT CHANNEL 1 jack.)
2. Select the DMM DC volts function, and enable auto-range.
3. From normal display. Press the Model 2500 SRC1 key, then set the channel 1 voltage bias source to the 10V range using the RANGE ▼ key.
4. Press the MENU key, select CAL, then press ENTER.
5. Select EXECUTE, then press ENTER to enter the CAL EXECUTION menu.
6. Select V-CAL then press ENTER. The unit will display the following:
   V-CAL CHANNEL SELECT
   CHAN-1 CHAN-2
7. Select CHAN-1 then press ENTER. The instrument will prompt for +10V calibration:
   V-CAL[1]
   Press ENTER to Output +10.000 V
8. Press ENTER. The instrument will display the following message:
   DMM RDG: 10.0000V
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
9. Note the DMM voltage reading, then use the EDIT keys to adjust the Model 2500 display value to agree with that reading.
10. Press ENTER. The unit will prompt for the 0V calibration point:
    V-CAL[1]
    Press ENTER to Output 00.000V
11. Press ENTER. The instrument will display the following message:
    DMM RDG: 00.00000 V
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
12. Note the DMM voltage reading, then use the EDIT keys to adjust the Model 2500 display value to agree with the reading.
13. Press ENTER. The unit will display the prompt for the -10V calibration point:
    V-CAL[1]
    Press ENTER to Output -10.000V
14. Press ENTER. The instrument will display the following message:
    DMM RDG: -10.00000 V
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
15. Note the DMM voltage reading, then use the EDIT keys to adjust the Model 2500 display value to agree with the reading, and press ENTER.
16. Press EXIT to return to normal display.

17. Using the appropriate RANGE key, select the 100V bias voltage range.
18. Repeat steps 4 through 15 for the 100V bias voltage range.

Table 2-4
Voltage bias calibration values

Voltage bias range	Calibration voltages
10V	+10.0000V 0.0000V -10.0000V
100V	+100.000V 0.000V -100.000V

Figure 2-1
Channel 1 voltage calibration connections



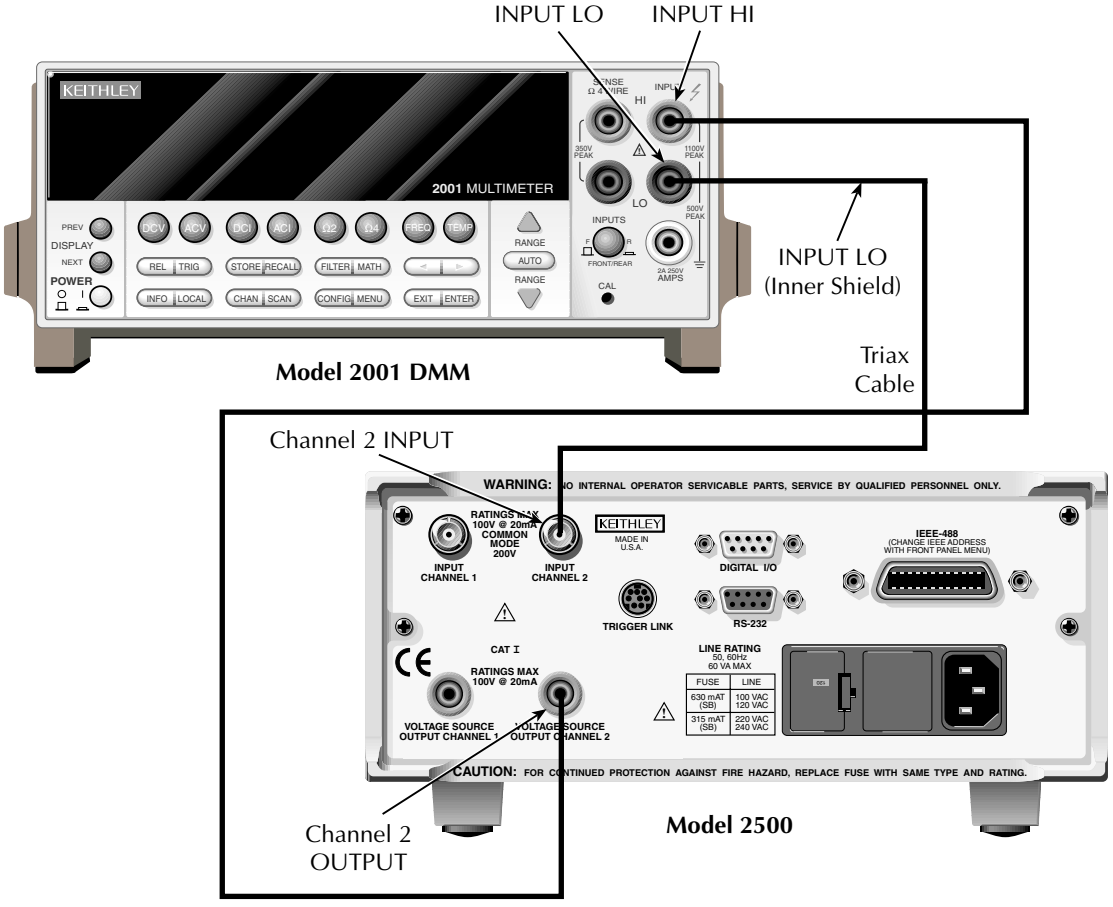
Step 4. Channel 2 voltage source calibration

Follow the steps below to calibrate both channel 2 bias voltage ranges. Table 2-4 summarizes calibration ranges and voltages.

1. Connect the DMM to the Model 2500 channel 2 INPUT and OUTPUT jacks, as shown in Figure 2-2. (Connect DMM INPUT HI to the VOLTAGE SOURCE OUTPUT CHANNEL 2 jack; connect DMM INPUT LO to the inner shield of the INPUT CHANNEL 2 jack.)
2. Select the DMM DC volts function, and enable auto-range.
3. From normal display, press the Model 2500 SRC2 key, then set the channel 2 voltage bias source to the 10V range using the RANGE ▼ key.
4. Press the MENU key, select CAL, then press ENTER.
5. Select EXECUTE, then press ENTER to enter the CAL EXECUTION menu.
6. Select V-CAL then press ENTER. The unit will display the following:
   V-CAL CHANNEL SELECT
   CHAN-1 CHAN-2
7. Select CHAN-2, then press ENTER. The instrument will prompt for +10V calibration:
   V-CAL[2]
   Press ENTER to Output +10.000 V
8. Press ENTER. The instrument will display the following message:
   DMM RDG: 10.0000V
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
9. Note the DMM voltage reading, then use the EDIT keys to adjust the Model 2500 display value to agree with that reading.
10. Press ENTER. The unit will prompt for the 0V calibration point:
    V-CAL[2]
    Press ENTER to Output 00.000V
11. Press ENTER. The instrument will display the following message:
    DMM RDG: 00.00000 V
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
12. Note the DMM voltage reading, then use the EDIT keys to adjust the Model 2500 display value to agree with the reading.
13. Press ENTER. The unit will display the prompt for the -10V calibration point:
    V-CAL[2]
    Press ENTER to Output -10.000V

14. Press ENTER. The instrument will display the following message:
    DMM RDG: -10.00000 V
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
15. Note the DMM voltage reading, then use the EDIT keys to adjust the Model 2500 display value to agree with the reading and press ENTER.
16. Press EXIT to return to normal display.
17. Using the appropriate RANGE key, select the 100V bias voltage range.
18. Repeat steps 4 through 15 for the 100V bias voltage range.

Figure 2-2
Channel 2 voltage calibration connections



Step 5. Channel 1 current calibration

Follow the steps below to calibrate all current ranges of channel 1. Table 2-5 summarizes calibration ranges and currents.

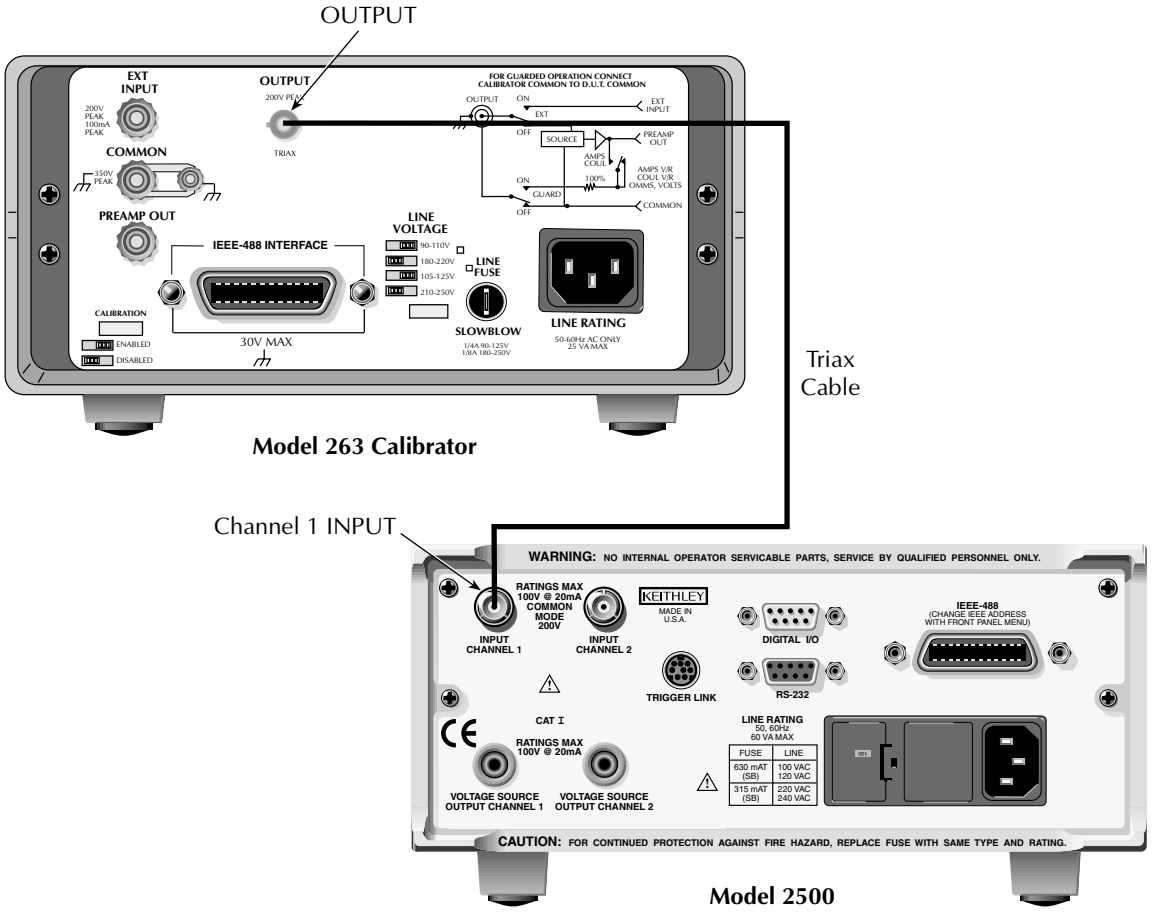
1. Connect the calibrator to the Model 2500 INPUT CHANNEL 1 jack, as shown in Figure 2-3.
2. Select the calibrator passive V/R amps function. Set the calibrator output to +1.90000nA and turn on the output.
3. Press the Model 2500 MSR1 key, then set channel 1 to the 2nA current range using the RANGE ▼ key.
4. Press the MENU key, select CAL, then press ENTER.
5. Select EXECUTE, then press ENTER to enter the CAL EXECUTION menu.
6. Select I-CAL then press ENTER. The unit will display the following:
   I -CAL CHANNEL SELECT
   CHAN-1 CHAN-2
7. Select CHAN-1 then press ENTER. The instrument will prompt for the positive full-range current:
   I (+FS)[1] = +2.000000nA
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
8. Set the calibrator current to +1.90000nA.
9. Use the EDIT keys to adjust the Model 2500 display value to agree with the calibrator current.
10. Press ENTER. The unit will prompt for the zero current:
    I (0)[1] = +0.000000nA
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
11. Set the calibrator current to 0nA then press ENTER. The instrument will prompt for the negative full-range current:
    I(-FS)[1] = -2.000000nA
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
12. Set the calibrator current to -1.90000nA.
13. Adjust the displayed current to agree with the calibrator current, then press the Model 2500 ENTER key to complete calibration of the present range.
14. Press EXIT to return to normal display.
15. Repeat steps 3 through 14 for the 20nA to 20mA ranges, using Table 2-5 as a guide. Be sure to set the Model 2500 to the correct range using the RANGE ▲ and ▼ keys, and use the corresponding calibrator currents for each range.

NOTE *Use the calibrator active amps mode for the 20mA range to assure best accuracy.*

Table 2-5
Current calibration values

Current range	Calibration currents
2nA	+1.90000nA 0.0000nA -1.90000nA
20nA	+19.0000nA 0.0000nA -19.0000nA
200nA	+190.000nA 0.000nA -190.000nA
2µA	+1.90000µA 0.00000µA -1.90000µA
20µA	+19.0000µA 0.0000µA -19.0000µA
200µA	+190.000µA 0.000µA -190.000µA
2mA	+1.90000mA 0.00000mA -1.90000mA
20mA	+19.0000mA 0.0000mA -19.0000mA

Figure 2-3
Channel 1 current calibration connections

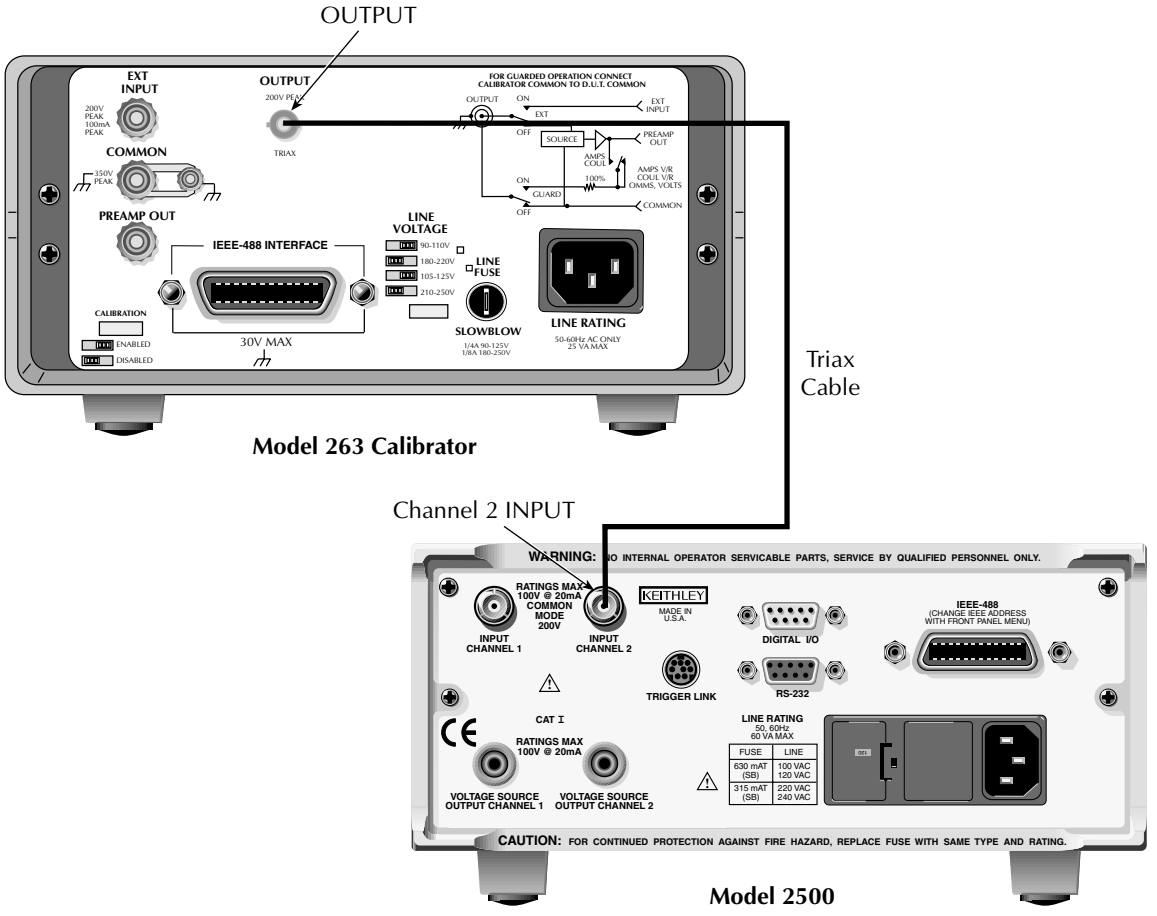


Step 6. Channel 2 current calibration

Follow the steps below to calibrate all channel 2 current ranges. Table 2-5 summarizes calibration ranges and currents.

1. Connect the calibrator to the Model 2500 INPUT CHANNEL 2 jack, as shown in Figure 2-4.
2. Select the calibrator passive V/R amps function. Set the calibrator output to +1.90000nA, and turn on the output.
3. Press the Model 2500 MSR2 key, then set channel 2 to the 2nA current range using the RANGE ▼ key.
4. Press the MENU key, select CAL, then press ENTER.
5. Select EXECUTE, then press ENTER to enter the CAL EXECUTION menu.
6. Select I-CAL then press ENTER. The unit will display the following:
   I -CAL CHANNEL SELECT
   CHAN-1 CHAN-2
7. Select CHAN-2 then press ENTER. The instrument will prompt for the positive full-range current:
   $I\ (+FS)^2$ = +2.000000nA
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
8. Set the calibrator current to +1.90000nA.
9. Use the EDIT keys to adjust the Model 2500 display value to agree with the calibrator current.
10. Press ENTER. The unit will prompt for the zero current:
    $I\ (0)^2$ = +0.000000nA
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
11. Set the calibrator current to 0nA then press ENTER. The instrument will prompt for the negative full-range current:
    $I(-FS)^2$ = -2.000000nA
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
12. Set the calibrator current to -1.90000nA.
13. Adjust the displayed current to agree with the calibrator current, then press the Model 2500 ENTER key to complete calibration of the present range.
14. Press EXIT to return to normal display.
15. Repeat steps 3 through 14 for the 20nA to 20mA ranges, using Table 2-5 as a guide. Be sure to set the Model 2500 to the correct range using the RANGE ▲ and ▼ keys, and use the corresponding calibrator currents for each range.

Figure 2-4
Channel 2 current calibration connections



Step 7. Enter calibration dates and save calibration

NOTE *For temporary calibration without saving new calibration constants, proceed to Step 8. Lock out calibration.*

1. From the CALIBRATION menu, select SAVE, and then press ENTER. The unit will prompt you for the calibration date:
   CAL DATE: 02/15/2000
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
2. Using the EDIT keys, change the displayed date to today's date and press the ENTER key. Press ENTER again to confirm the date.
3. The unit will then prompt for the calibration due date:
   NEXT CAL: 02/15/2001
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
4. Set the calibration due date to the desired value and press ENTER. Press ENTER again to confirm the date.
5. Once the calibration dates are entered calibration is complete, and the following message will be displayed:
   CALIBRATION COMPLETE
   Press ENTER to save; EXIT to abort
6. Press ENTER to save the calibration data (or press EXIT to abort without saving calibration data.)

Step 8. Lock out calibration

From the CAL EXECUTION menu select LOCK, and press ENTER to lock out calibration. Press EXIT to return to normal display.

Remote calibration

Use the following procedure to perform remote calibration by sending SCPI commands over the IEEE-488 bus or RS-232 port. The remote commands and appropriate parameters are separately summarized for each step.

Remote calibration command summary

Table 2-6 summarizes only those remote calibration commands used in this section.

NOTE *For a detailed description of all calibration commands and queries, refer to Appendix B.*

Table 2-6
Remote calibration command summary

Command	Description
:CALibration	Calibration subsystem.
:PROTected	Calibration commands protected by password.
:CODE '<password>'	Unlock calibration. (Default password: KI002500.)
:SENSe[1] <NRf>	Calibrate active range of channel 1 current measurement.
:SENSe2 <NRf>	Calibrate active range of channel 2 current measurement.
:SOURce[1] <NRf>	Calibrate active channel 1 voltage bias range.
:OFFSet	Calibrate channel 1 input voltage offset.
:SOURce2 <NRf>	Calibrate active channel 2 voltage bias range.
:OFFSet	Calibrate channel 2 input voltage offset.
:DATE <yyyy>,<mm>,<dd>	Program calibration year, month, day.
:NDUE <yyyy>,<mm>,<dd>	Program calibration due year, month, day.
:SAVE	Save calibration data in EEPROM.
:LOCK	Lock out calibration.

Remote calibration procedure

Step 1. Prepare the Model 2500 for calibration

1. With the power off, connect the Model 2500 to the controller IEEE-488 interface or RS-232 port using a shielded interface cable.
2. Turn on the Model 2500 and the test equipment, and allow them to warm up for at least one hour before performing calibration.
3. If you are using the IEEE-488 interface, make sure the primary address of the Model 2500 is the same as the address specified in the program you will be using to send commands. (Use the MENU key and the COMMUNICATION menu to access the IEEE-488 address.)

4. Send the following command to unlock calibration:
   :CAL:PROT:CODE 'KI002500'
5. Table 2-7 summarizes the various calibration steps and associated commands, which are covered in more detail throughout the procedure.

Table 2-7
Remote calibration step summary

Calibrated function	Calibration command*	Test connections
Input offset (ch. 1)	:CAL:PROT:SOUR1:OFFS	Triax shield cap on channel 1 INPUT jack.
Voltage bias (ch. 1)	:OUTP1 ON :SOUR1:VOLT:RANG <Range> :SOUR1:VOLT <+FS> :CAL:PROT:SOUR1 <DMM_Reading> :SOUR1:VOLT 0 :CAL:PROT:SOUR1 <DMM_Reading> :SOUR1:VOLT <-FS> :CAL:PROT:SOUR1 <DMM_Reading> :OUTP1 OFF :OUTP2 ON :SOUR2:VOLT:RANG <Range> :SOUR2:VOLT <+FS>	 DMM to channel 1 OUTPUT/INPUT LO (Figure 2-1) DMM to channel 1 OUTPUT/INPUT LO (Figure 2-1) DMM to channel 1 OUTPUT/INPUT LO (Figure 2-1) DMM to channel 2 OUTPUT/INPUT LO (Figure 2-2)
Input offset (ch. 2)	:CAL:PROT:SOUR2:OFFS	Triax shield cap on channel 2 INPUT jack.
Voltage bias (ch. 2)	:CAL:PROT:SOUR2 <DMM_Reading> :SOUR2:VOLT 0 :CAL:PROT:SOUR2 <DMM_Reading> :SOUR2:VOLT <-FS> :CAL:PROT:SOUR2 <DMM_Reading> :OUTP2 OFF	 DMM to channel 2 OUTPUT/INPUT LO (Figure 2-2) DMM to channel 2 OUTPUT/INPUT LO (Figure 2-2)
Current (ch. 1)	:SENS1:CURR:RANG <Range> :CAL:PROT:SENS1 <+FS_current> :CAL:PROT:SENS1 <Zero_current> :CAL:PROT:SENS1 <-FS_current> :SENS2:CURR:RANG <Range>	Calibrator to channel 1 INPUT (Figure 2-3) Calibrator to channel 1 INPUT (Figure 2-3) Calibrator to channel 1 INPUT (Figure 2-3) Calibrator to channel 2 INPUT (Figure 2-4)
Current (ch. 2)	:CAL:PROT:SENS2 <+FS_current> :CAL:PROT:SENS2 <Zero_current> :CAL:PROT:SENS2 <-FS_current>	Calibrator to channel 2 INPUT (Figure 2-4) Calibrator to channel 2 INPUT (Figure 2-4) Calibrator to channel 2 INPUT (Figure 2-4)

*Procedure repeated separately for each range. Voltage <Range> = 10 or 100. Current <Range> = 2e-9 to 20e-3 in decade steps.

Step 2. Channel 1 input offset voltage calibration

1. Install a triax shielding cap on the channel 1 INPUT jack.
2. Send this command to calibrate channel 1 input offset voltage:
   :CAL:PROT:SOUR1:OFFS

Step 3. Channel 1 voltage source calibration

Follow these steps to calibrate the channel 1 voltage bias source. Table 2-8 summarizes channel 1 calibration voltages and commands.

1. Connect the DMM to the Model 2500 channel 1 OUTPUT and INPUT LO terminals, as shown in Figure 2-1.
2. Select the DMM DC voltage function and enable auto-range.
3. Send this command to turn on the channel 1 output:
   :OUTP1 ON
4. Send the following command to select the channel 1 10V voltage bias range:
   :SOUR1:VOLT:RANG 10
5. Send the following command to output +10V:
   :SOUR1:VOLT 10
6. Note and record the DMM reading, and send that value as the parameter for the following command:
   :CAL:PROT:SOUR1 <DMM_Reading>
   For example, if the DMM reading is 9.95V, the correct command is:
   :CAL:PROT:SOUR1 9.95
7. Send the following command to output 0V:
   :SOUR1:VOLT 0
8. Note and record the DMM reading, and send that value as the parameter for the following command:
   :CAL:PROT:SOUR1 <DMM_Reading>
9. Send the following command to output -10V:
   :SOUR1:VOLT -10
10. Note and record the DMM reading, and send that value as the parameter for the following command:
    :CAL:PROT:SOUR1 <DMM_Reading>
11. Repeat steps 4 through 10 for the 100V range using Table 2-8 as a guide. Be sure to:
    - Select the 100V range using the :SOUR1:VOLT:RANG 100 command.
    - Send the ±100V source values where appropriate.
12. Send this command to turn off the channel 1 output:
    :OUTP1 OFF

Table 2-8
Channel 1 remote voltage bias calibration summary

Voltage bias range	Calibration voltages	Calibration commands
10V		:OUTP1 ON :SOUR1:VOLT:RANG 10
	+10V	:SOUR1:VOLT 10 :CAL:PROT:SOUR1 <DMM_Reading>
	0V	:SOUR1:VOLT 0 :CAL:PROT:SOUR1 <DMM_Reading>
	-10V	:SOUR1:VOLT -10 :CAL:PROT:SOUR1 <DMM_Reading>
100V		:SOUR1:VOLT:RANG 100
	+100V	:SOUR1:VOLT 100 :CAL:PROT:SOUR1 <DMM_Reading>
	0V	:SOUR1:VOLT 0 :CAL:PROT:SOUR1 <DMM_Reading>
	-100V	:SOUR1:VOLT -100 :CAL:PROT:SOUR1 <DMM_Reading> :OUTP1 OFF

Step 4. Channel 2 input offset voltage calibration

1. Install a triax shielding cap on the channel 2 INPUT jack.
2. Send this command to calibrate channel 2 input offset voltage:
   :CAL:PROT:SOUR2:OFFS

Step 5. Channel 2 voltage source calibration

Follow these steps to calibrate the channel 2 voltage bias source. Table 2-9 summarizes channel 1 calibration voltages and commands.

1. Connect the DMM to the Model 2500 channel 2 OUTPUT and INPUT LO terminals, as shown in Figure 2-2.
2. Select the DMM DC voltage function, and enable auto-range.
3. Send this command to turn on the channel 2 output:
   :OUTP2 ON
4. Send the following command to select the channel 2 10V voltage bias range:
   :SOUR2:VOLT:RANG 10
5. Send the following command to output +10V:
   :SOUR2:VOLT 10

6. Note and record the DMM reading, and send that value as the parameter for the following command:
   :CAL:PROT:SOUR2 <DMM_Reading>
7. Send the following command to output 0V:
   :SOUR2:VOLT 0
8. Note and record the DMM reading, and send that value as the parameter for the following command:
   :CAL:PROT:SOUR2 <DMM_Reading>
9. Send the following command to output -10V:
   :SOUR2:VOLT -10
10. Note and record the DMM reading, and send that value as the parameter for the following command:
    :CAL:PROT:SOUR2 <DMM_Reading>
11. Repeat steps 4 through 10 for the 100V range using Table 2-9 as a guide. Be sure to:
    - Select the 100V range using the :SOUR2:VOLT:RANG 100 command.
    - Send the ±100V source values where appropriate.
12. Send this command to turn off the channel 1 output:
    :OUTP2 OFF

Table 2-9
Channel 2 remote voltage bias calibration summary

Voltage bias range	Calibration voltages	Calibration commands
10V		:OUTP2 ON :SOUR2:VOLT:RANG 10
	+10V	:SOUR2:VOLT 10 :CAL:PROT:SOUR2 <DMM_Reading>
	0V	:SOUR2:VOLT 0 :CAL:PROT:SOUR2 <DMM_Reading>
	-10V	:SOUR2:VOLT -10 :CAL:PROT:SOUR2 <DMM_Reading>
100V		:SOUR2:VOLT:RANG 100
	+100V	:SOUR2:VOLT 100 :CAL:PROT:SOUR2 <DMM_Reading>
	0V	:SOUR2:VOLT 0 :CAL:PROT:SOUR2 <DMM_Reading>
	-100V	:SOUR2:VOLT -100 :CAL:PROT:SOUR2 <DMM_Reading> :OUTP2 OFF

Step 6. Channel 1 current calibration

Follow these steps to calibrate channel 1 current measurements. Table 2-10 summarizes channel 1 calibration currents and commands.

Table 2-10
Channel 1 calibration currents and commands

Current range	Calibration currents	Calibration commands
2nA		:SENS1:CURR:RANG 2e-9
	+1.90000nA	:CAL:PROT:SENS1 1.9e-9
	0.00000nA	:CAL:PROT:SENS1 0
	-1.90000nA	:CAL:PROT:SENS1 -1.9e-9
20nA		:SENS1:CURR:RANG 2e-8
	+19.0000nA	:CAL:PROT:SENS1 1.9e-8
	0.0000nA	:CAL:PROT:SENS1 0
	-19.0000nA	:CAL:PROT:SENS1 -1.9e-8
200nA		:SENS1:CURR:RANG 2e-7
	+190.000nA	:CAL:PROT:SENS1 1,9e-7
	0.000nA	:CAL:PROT:SENS1 0
	-190.000nA	:CAL:PROT:SENS1 -1.9e-7
2µA		:SENS1:CURR:RANG 2e-6
	+1.90000µA	:CAL:PROT:SENS1 1.9e-6
	0.00000µA	:CAL:PROT:SENS1 0
	-1.90000µA	:CAL:PROT:SENS1 -1.9e-6
20µA		:SENS1:CURR:RANG 2e-5
	+19.0000µA	:CAL:PROT:SENS1 1.9e-5
	0.0000µA	:CAL:PROT:SENS1 0
	-19.0000µA	:CAL:PROT:SENS1 -1.9e-5
200µA		:SENS1:CURR:RANG 2e-4
	+190.000µA	:CAL:PROT:SENS1 1.9e-4
	0.000µA	:CAL:PROT:SENS1 0
	-190.000µA	:CAL:PROT:SENS1 -1.9e-4
2mA		:SENS1:CURR:RANG 2e-3
	+1.90000mA	:CAL:PROT:SENS1 1.9e-3
	0.0000mA	:CAL:PROT:SENS1 0
	-1.90000mA	:CAL:PROT:SENS1 -1.9e-3
20mA		:SENS1:CURR:RANG 2e-2
	+19.0000mA	:CAL:PROT:SENS1 1.9e-2
	0.0000mA	:CAL:PROT:SENS1 0
	-19.0000mA	:CAL:PROT:SENS1 -1.9e-2

1. Connect the calibrator to the Model 2500 INPUT CHANNEL 1 jack, as shown in Figure 2-3.
2. Select the calibrator passive V/R amps function. Set the output current to 1.90000nA, and turn on the calibrator output.
3. Send the following command to select the channel 1 2nA range:
   :SENS1:CURR:RANG 2e-9
4. Send the following command to calibrate the positive full-range current point:
   :CAL:PROT:SENS1 1.9e-9
5. Set the calibrator current output to 0nA.
6. Send the following command to calibrate the zero current point:
   :CAL:PROT:SENS1 0
7. Set the calibrator current to -1.90000nA.
8. Send the following command to calibrate the negative full-range current point:
   :CAL:PROT:SENS1 -1.9e-9
9. Repeat steps 3 through 8 for the 20nA to 20mA ranges using Table 2-10 as a guide. Be sure to:
   - Select the appropriate range using the :SENS1:CURR:RANG <Range> command.
   - Send the appropriate calibration current values with the :CAL:PROT:SENS1 <Current> command.
   - Be sure to use the calibrator active amps mode for the 20mA range.

Step 7. Channel 2 current calibration

Follow these steps to calibrate channel 2 current measurements. Table 2-11 summarizes channel 2 calibration currents and commands.

1. Connect the calibrator to the Model 2500 INPUT CHANNEL 2 jack, as shown in Figure 2-4.
2. Select the calibrator passive V/R amps function. Set the output current to 1.90000nA, and turn on the calibrator output.
3. Send the following command to select the channel 2 2nA range:
   :SENS2:CURR:RANG 2e-9
4. Send the following command to calibrate the positive full-range current point:
   :CAL:PROT:SENS2 1.9e-9
5. Set the calibrator current to 0nA.
6. Send the following command to calibrate the zero current point:
   :CAL:PROT:SENS2 0
7. Set the calibrator current to -1.90000nA.
8. Send the following command to calibrate the negative full-range current point:
   :CAL:PROT:SENS2 -1.9e-9

9. Repeat steps 3 through 8 for the 20nA to 20mA ranges using Table 2-11 as a guide. Be sure to:
   - Select the appropriate range using the :SENS2:CURR:RANG <Range> command.
   - Send the appropriate calibration current values with the :CAL:PROT:SENS2 <Current> command.
   - Use the calibrator active amps mode for the 20mA range.

Table 2-11
Channel 2 calibration currents and commands

Current range	Calibration currents	Calibration commands
2nA		:SENS2:CURR:RANG 2e-9
	+1.90000nA	:CAL:PROT:SENS2 1.9e-9
	0.0000nA	:CAL:PROT:SENS2 0
	-1.90000nA	:CAL:PROT:SENS2 -1.9e-9
20nA		:SENS2:CURR:RANG 2e-8
	+19.0000nA	:CAL:PROT:SENS2 1.9e-8
	0.0000nA	:CAL:PROT:SENS2 0
	-19.0000nA	:CAL:PROT:SENS2 -1.9e-8
200nA		:SENS2:CURR:RANG 2e-7
	+190.000nA	:CAL:PROT:SENS2 1.9e-7
	0.0000nA	:CAL:PROT:SENS2 0
	-190.000nA	:CAL:PROT:SENS2 -1.9e-7
2µA		:SENS2:CURR:RANG 2e-6
	+1.90000µA	:CAL:PROT:SENS2 1.9e-6
	0.00000µA	:CAL:PROT:SENS2 0
	-1.90000µA	:CAL:PROT:SENS2 -1.9e-6
20µA		:SENS2:CURR:RANG 2e-5
	+19.0000µA	:CAL:PROT:SENS2 1.9e-5
	0.00000µA	:CAL:PROT:SENS2 0
	-19.0000µA	:CAL:PROT:SENS2 -1.9e-5
200µA		:SENS2:CURR:RANG 2e-4
	+190.000µA	:CAL:PROT:SENS2 1.9e-4
	0.0000µA	:CAL:PROT:SENS2 0
	-190.000µA	:CAL:PROT:SENS2 -1.9e-4
2mA		:SENS2:CURR:RANG 2e-3
	+1.90000mA	:CAL:PROT:SENS2 1.9e-3
	0.0000mA	:CAL:PROT:SENS2 0
	-1.90000mA	:CAL:PROT:SENS2 -1.9e-3
20mA		:SENS2:CURR:RANG 2e-2
	+19.0000mA	:CAL:PROT:SENS2 1.9e-2
	0.0000mA	:CAL:PROT:SENS2 0
	-19.0000mA	:CAL:PROT:SENS2 -1.9e-2

Step 8. Program calibration dates

Use following commands to set the calibration date and calibration due date:

:CAL:PROT:DATE	<yyyy>, <mm>, <dd>	(Calibration date)
:CAL:PROT:NDUE	<yyyy>, <mm>, <dd>	(Next calibration due date)

Note that the year, month, and date must be separated by commas.

Step 9. Save calibration constants

Calibration is now complete, so you can store the calibration constants in EEROM by sending the following command:

```
:CAL:PROT:SAVE
```

NOTE *Calibration will be temporary unless you send the SAVE command.*

Step 10. Lock out calibration

To lock out further calibration, send the following command after completing the calibration procedure:

```
:CAL:PROT:LOCK
```

3
Routine Maintenance

Introduction

The information in this section deals with routine type maintenance that can be performed by the operator and includes information on line voltage selection and line fuse replacement.

Line voltage selection

WARNING **Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before changing the line voltage.**

The Model 2500 operates from a line voltage in the range of 100V / 120V / 220V / 240V, ±10% at a frequency of 50 or 60Hz. Before plugging in the unit, make sure the line voltage setting seen through the small window in the power module (Figure 3-1) is correct for the line voltage in your area.

WARNING **Operating the instrument on an incorrect line voltage may cause damage, possibly voiding the warranty.**

If the voltage setting is not correct, change it as outlined below.

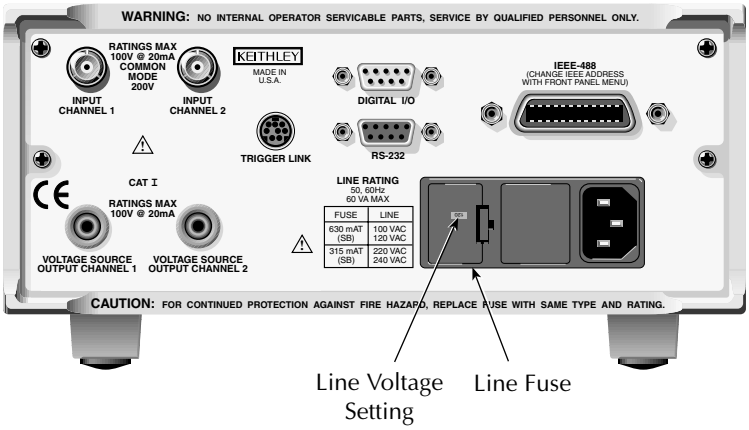
1. Pry the small tab that secures the fuse holder to the power module, then remove the fuse holder.
2. Pull out and rotate the fuse carrier to the correct line voltage setting, then install it in the fuse holder. Make sure the line voltage shown in the window is correct. Also make sure the fuse rating for the expected line voltage is correct. (See "Line fuse replacement.")
3. Reinstall the fuse holder in the power module, making sure it is seated fully.

Line fuse replacement

WARNING **Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before replacing the line fuse.**

The power line fuse is accessible from the rear panel and is integral with the AC power module (Figure 3-1).

Figure 3-1
Model 2500 rear panel



Perform the following steps to replace the line fuse:

1. Using a small flat-blade screwdriver, carefully release the locking tab that secures the fuse carrier to the power module.
2. Pull out the fuse carrier, and replace the fuse with the type specified in Table 3-1.

CAUTION **To prevent instrument damage, use only the fuse type specified in Table 3-1.**

3. Reinstall the fuse carrier, pushing it in firmly until it locks into place.

NOTE *If the power line fuse continues to blow, a circuit malfunction exists and must be corrected. Refer to the troubleshooting information in Section 4 of this manual for additional information.*

Table 3-1
Power line fuses

Line voltage	Fuse rating	Keithley part no.
100V, 120V	0.630A Slo Blo, 250V, 5 × 20mm	FU-106-.630
220V, 240V	0.315A Slo Blo, 250V, 5 × 20mm	FU-106-.315

4
Troubleshooting

Introduction

This section of the manual will assist you in troubleshooting and repairing the Model 2500 Dual Photodiode Meter. Included are self tests, test procedures, troubleshooting tables, and circuit descriptions. Note that disassembly instructions are located in Section 5, and component layout drawings are at the end of Section 6.

Safety considerations

WARNING **The information in this section is intended for qualified service personnel only. Do not perform these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages that could cause personal injury or death. Use caution when working with hazardous voltages.**

Repair considerations

Before making any repairs to the Model 2500, be sure to read the following considerations.

CAUTION **The PC boards are built using surface mount techniques and require specialized equipment and skills for repair. If you are not equipped and/or qualified, it is strongly recommended that you send the unit back to the factory for repairs or limit repairs to the PC board replacement level. Without proper equipment and training, you could damage a PC board beyond repair.**

- Repairs will require various degrees of disassembly. However, it is recommended that the Front Panel Tests be performed prior to any disassembly. The disassembly instructions for the Model 2500 are contained in Section 5 of this manual.
- Do not make repairs to surface mount PC boards unless equipped and qualified to do so.
- When working inside the unit and replacing parts, be sure to adhere to the handling precautions and cleaning procedures explained in Section 5.
- Many CMOS devices are installed in the Model 2500. These static-sensitive devices require special handling as explained in Section 5.
- Whenever a circuit board is removed or a component is replaced, the Model 2500 must be recalibrated. See Section 2 for details on calibrating the unit.

Power-on self test

During the power-on sequence, the Model 2500 will perform a checksum test on its EPROM and test its RAM. If one of these tests fails, the instrument will lock up.

Front panel tests

There are three front panel tests: one to test the functionality of the front panel keys and two to test the display. In the event of a test failure, refer to "Display board checks" for details on troubleshooting the display board.

KEYS test

The KEYS test lets you check the functionality of each front panel key. Perform the following steps to run the KEYS test.

1. Display the MAIN MENU by pressing the MENU key.
2. Using the EDIT keys, select TEST, and press ENTER to display the SELF-TEST MENU.
3. Select DISPLAY-TESTS, and press ENTER to display the following menu:
   FRONT PANEL TESTS
   KEYS DISPLAY-PATTERNS CHAR-SET
4. Select KEYS, and press ENTER to start the test. When a key is pressed, the label name for that key will be displayed to indicate that it is functioning properly. When the key is released, the message NO KEYS PRESSED is displayed.
5. Pressing EXIT tests the EXIT key. However, the second consecutive press of EXIT aborts the test and returns the instrument to the SELF-TEST MENU. Continue pressing EXIT to back out of the menu structure.

DISPLAY PATTERNS test

The display test lets you verify that each pixel and annunciator in the vacuum fluorescent display is working properly. Perform the following steps to run the display test:

1. Display the MAIN MENU by pressing the MENU key.
2. Select TEST, and press ENTER to display the SELF-TEST MENU.
3. Select DISPLAY-TESTS, and press ENTER to display the following menu:
   FRONT PANEL TESTS
   KEYS DISPLAY-PATTERNS CHAR-SET

4. Select DISPLAY-PATTERNS, and press ENTER to start the display test. There are five parts to the display test. Each time a front panel key (except EXIT) is pressed, the next part of the test sequence is selected. The five parts of the test sequence are as follows:
   - Checkerboard pattern (alternate pixels on) and all annunciators.
   - Checkerboard pattern and the annunciators that are on during normal operation.
   - Horizontal lines (pixels) of the first digit are sequenced.
   - Vertical lines (pixels) of the first digit are sequenced.
   - Each digit (and adjacent annunciator) is sequenced. All the pixels of the selected digit are on.
5. When finished, abort the display test by pressing EXIT. The instrument returns to the FRONT PANEL TESTS MENU. Continue pressing EXIT to back out of the menu structure.

CHAR SET test

The character set test lets you display all characters. Perform the following steps to run the character set test:

1. Display the MAIN MENU by pressing the MENU key.
2. Select TEST, and press ENTER to display the SELF-TEST MENU.
3. Select DISPLAY-TESTS, and press ENTER to display the following menu:
   FRONT PANEL TESTS
   KEYS DISPLAY-PATTERNS CHAR-SET
4. Select CHAR-SET, and press ENTER to start the character set test. Press any key except EXIT to cycle through all displayable characters.
5. When finished, abort the character set test by pressing EXIT. The instrument returns to the FRONT PANEL TESTS MENU. Continue pressing EXIT to back out of the menu structure.

Principles of operation

The following information is provided to support the troubleshooting tests and procedures covered in this section of the manual. Refer to the following drawings:

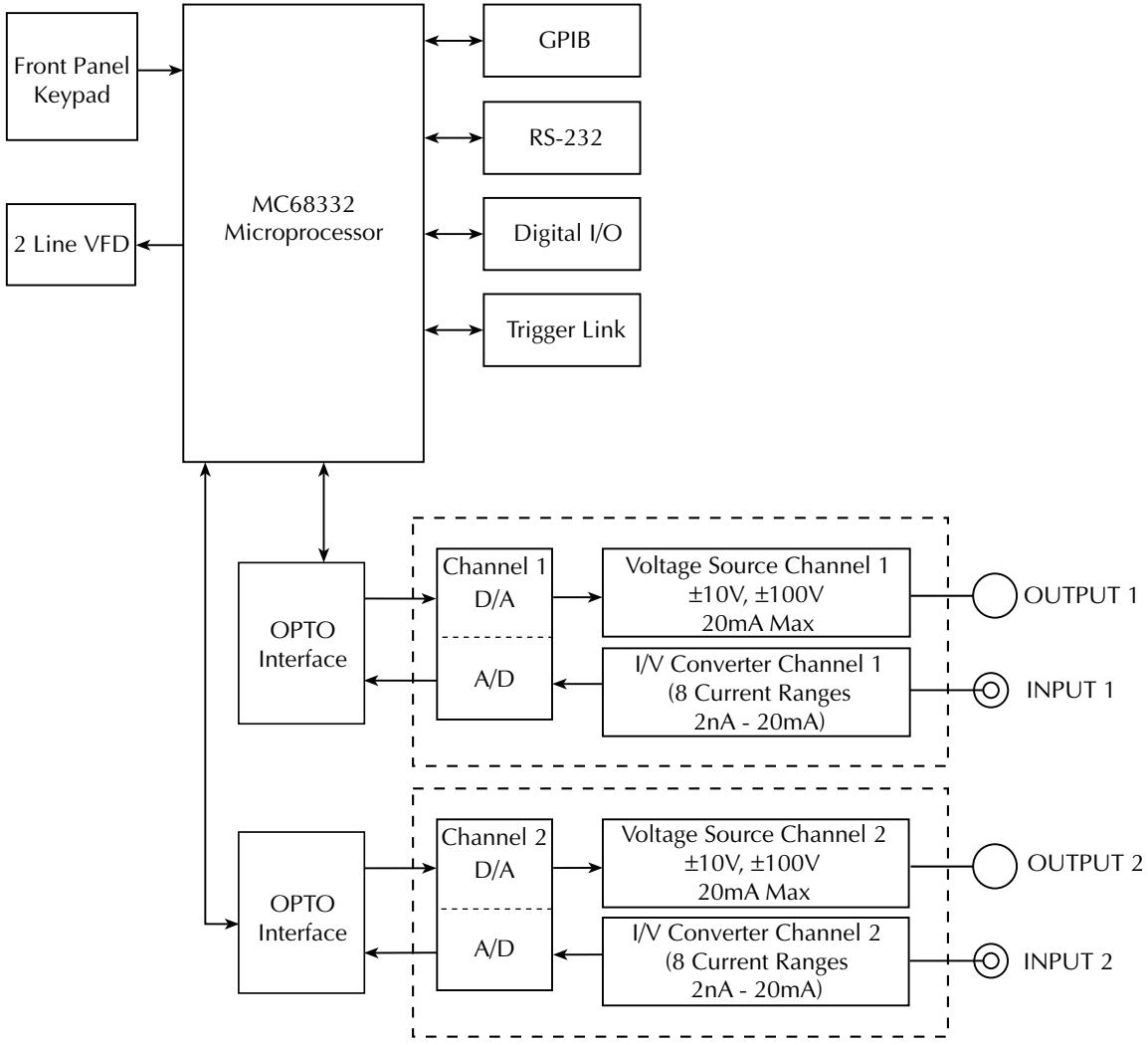
Figure 4-1 — Overall block diagram
Figure 4-2 — Analog circuitry block diagram
Figure 4-3 — Power supply block diagram
Figure 4-4 — Digital circuitry block diagram

Overall block diagram

Figure 4-1 shows an overall block diagram of the Model 2500. Circuitry may be divided into two general areas:

- Analog circuits — includes measurement circuits such as the I/V converter, mux, and A/D converter, as well as voltage bias circuits.
- Digital circuits — includes the microcomputer that controls the analog section, front panel, and GPIB and RS-232 ports, as well as associated interfacing circuits.

Figure 4-1
Overall block diagram



Analog circuits

Figure 4-2 shows a simplified block diagram of the analog circuits.

Current measurement circuits

Signal conditioning for the input current is provided by an I/V converter, which converts the input signal current to voltage that can be used by the A/D converter. Current ranging is provided by selecting various feedback resistors and switching in an X10 gain amplifier at appropriate times. The multiplexer (not shown) switches among different signals during the various phases of the measurement cycle, and passes the signal along to the A/D converter.

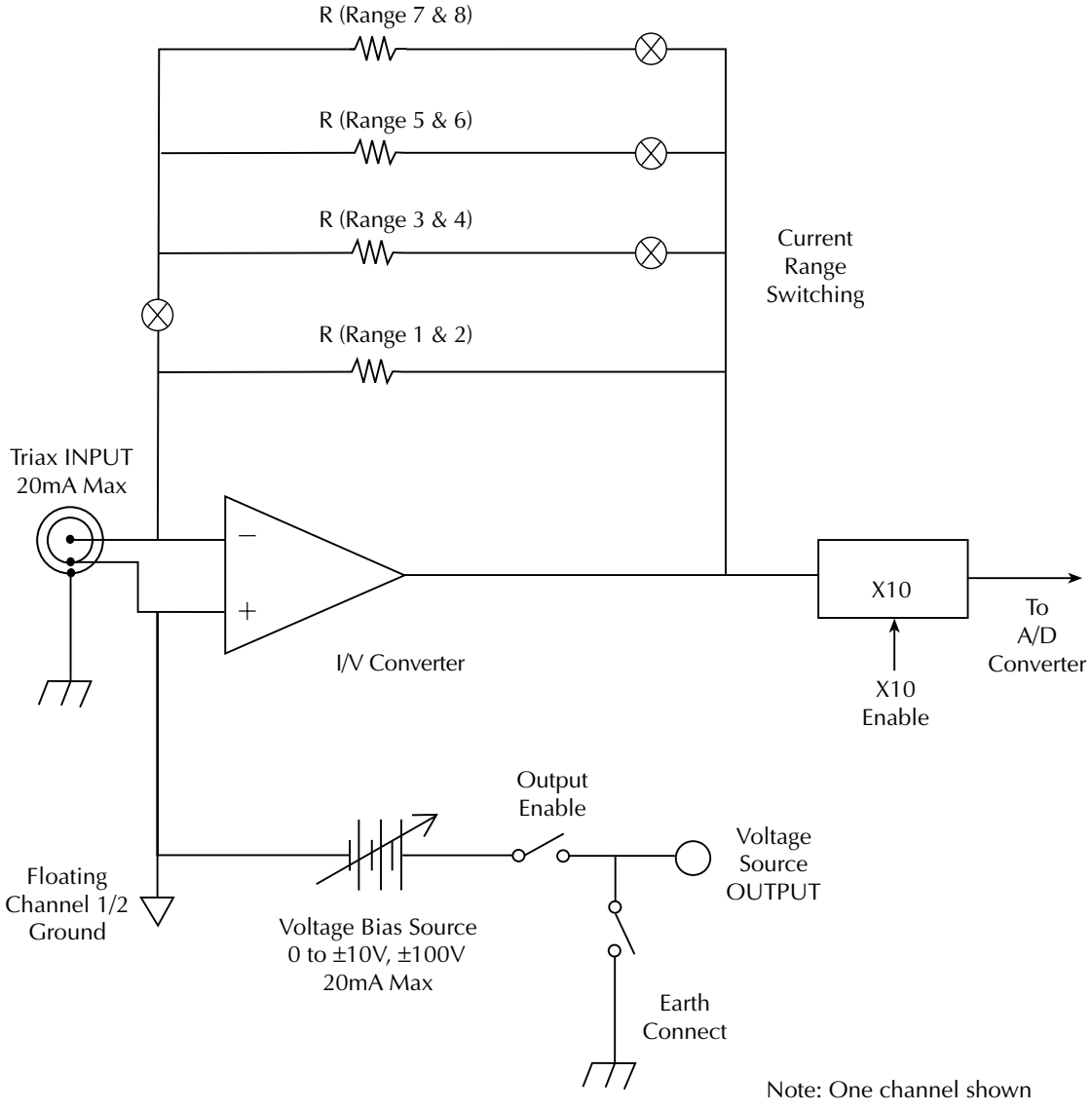
A/D converter

Each Model 2500 channel uses a multi-slope charge balance A/D converter with a single-slope run-down. The converter is controlled by a gate array. Commands are issued by the MPU to the gate array, and the gate array IC sends A/D reading data back to the MPU for calibration and processing.

Bias voltage circuits

Each Model 2500 voltage bias source is a digitally controlled source that can source up to ±100V @ 20mA. Digital control information from the MPU is converted into an equivalent analog signal, which is amplified to provide the full ±100V, 20mA output capability. Source ranging (10V or 100V) is performed by controlling the overall gain of the amplifier stage. Compliance circuitry detects when the output current exceeds a fixed 20mA limit and sends an over-compliance flag bit back to the MPU.

Figure 4-2
Analog circuitry block diagram



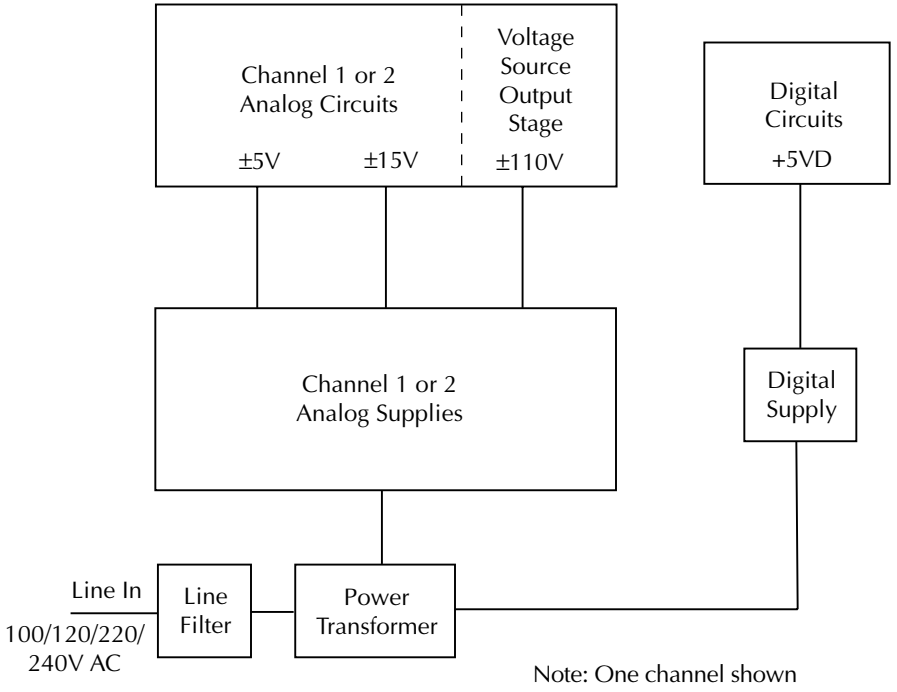
Power supply

Figure 4-3 shows a block diagram of the Model 2500 power supply system.

NOTE *There are two identical power supply systems in the Model 2500, one for each channel. Only one power supply is shown in Figure 4-3.*

Regulated circuits include ±5V and ±15V to power the analog circuits, and a separate +5VD supply to power digital circuits. Unregulated ±110V supplies power to the bias source output stages.

Figure 4-3
Power supply block diagram



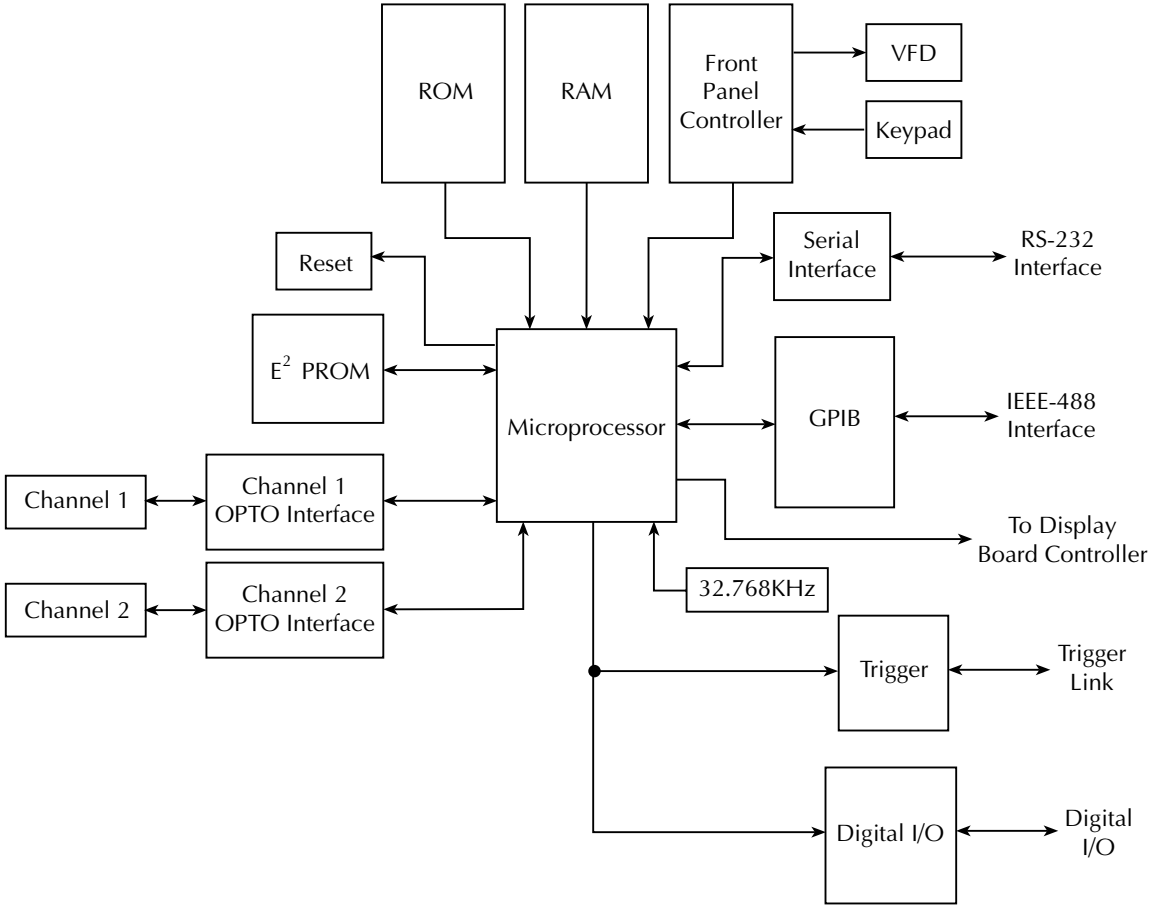
Digital circuitry

Refer to Figure 4-4 for the following discussion on digital circuitry.

The core digital circuitry uses a Motorola 68332 microcontroller running at 20MHz. The memory configuration includes a flash EEPROM and a RAM. Flash ROM support allows internal firmware upgrades using either the serial or GPIB port for downloading new firmware. All calibration constants and the saved setups are stored in a separate serial EEPROM.

External communication is provided via GPIB and serial interfaces. A 9914 GPIB IEEE-488 with standard interface ICs are used for the GPIB, and an IC to provide the voltage conversion for the RS-232 port.

Figure 4-4
Digital circuitry block diagram



Display board circuits

The display board includes a microcontroller that controls the Vacuum Fluorescent Display (VFD) and interprets key data. The microcontroller has four peripheral I/O ports that are used for the various control and read functions.

The VFD module can display up to 52 characters. Each character is organized as a 5×7 matrix of dots or pixels and includes a long under-bar segment to act as a cursor. The display uses a common multiplexing scheme with each character refreshed in sequence. Circuitry includes the grid drivers and dot drivers.

Troubleshooting

Troubleshooting information for the various circuits is summarized below. Refer to the component layout drawings at the end of Section 6 for component locations.

Display board checks

If the front panel display tests indicate that there is a problem on the display board, use Table 4-1. See "Principles of operation" for display circuit theory.

Table 4-1
Display board checks

Step	Item/ component	Required condition	Remarks
1	Front panel test	Verify that all segments operate.	Use front panel display test.
2	J1033	+5V, ±5%	Digital +5V supply.
3	U902, pin 1	Goes low briefly on power up, and then goes high.	Microcontroller RESET.
4	U902, pin 43	4MHz square wave.	Controller 4MHz clock.
5	U902, pin 32	Pulse train every 1ms.	Control from main processor.
6	U902, pin 33	Brief pulse train when front panel key is pressed.	Key down data sent to main processor.

Power supply checks

Power supply problems can be checked out using Table 4-2. See "Principles of operation" for circuit theory on the power supply.

Table 4-2
Power supply checks

Step	Item/component*	Required condition	Remarks
1	Line fuse	Check continuity.	Remove to check.
2	Line power	Plugged into live receptacle, power on.	Check for correct power-up sequence.
3	+5VDA TP	+5V, ±5%	Referenced to GND DA TP.
4	+5VA TP	+15V ±5%	Referenced to GND A TP.
5	-15VA TP	-15V, ±5%	Referenced to GND A TP.
6	+5VA TP	+5V, ±5%	Referenced to GND A TP.
7	-5VA TP	-5V, ±5%	Referenced to GND A TP.
8	+110VA TP	+110V, ±20%	Referenced to GND A TP.
9	-110VA TP	-110V, ±20%	Referenced to GND A TP.
10	+5VDB TP	+5V, ±5%	Referenced to GND DB TP.
11	+5VB TP	+15V ±5%	Referenced to GND B TP.
12	-15VB TP	-15V, ±5%	Referenced to GND B TP.
13	+5VB TP	+5V, ±5%	Referenced to GND B TP
14	-5VB TP	-5V, ±5%	Referenced to GND B TP.
15	+110VB TP	+110V, ±20%	Referenced to GND B TP.
16	-110VB TP	-110V, ±20%	Referenced to GND B TP.

*Test points (TP) are marked on circuit board.

Digital circuitry checks

Digital circuit problems can be checked out using Table 4-3. See "Principles of operation" for a digital circuit description.

Table 4-3
Digital circuitry checks

Step	Item/component	Required condition	Remarks
1	Power-on test	RAM OK, ROM OK.	Verify that RAM and ROM are functional.
2	U163 pin 19	Digital common.	All signals referenced to digital common.
3	U163 pin 7	+5V	Digital logic supply.
4	U163 pin 68	Low on power-up, then goes high.	MPU RESET line.
5	U163, A0-A19	Check for stuck bits.	MPU address bus.
6	U163, D0-D15	Check for stuck bits.	MPU data bus.
7	U163 pin 66	20MHz.	MPU clock.
8	U166 pin 7	Pulse train during RS-232 I/O.	RS-232 TX line.
9	U166 pin 8	Pulse train during RS-232 I/O.	RS-232 RX line.
10	U167 pins 34-42	Pulse train during IEEE-488 I/O.	IEEE-488 data bus.
11	U167 pins 26, 27, 29-32	Pulses during IEEE-488 I/O.	IEEE-488 command lines.
12	U167 pin 24	Low with remote enabled.	IEEE-488 REN line.
13	U167 pin 25	Low during interface clear.	IEEE-488 IFC line.
14	U163 pin 43	Pulse train.	ADRXB
15	U171 pin 4	Pulse train.	ADTX
16	U163 pin 45	Pulse train.	AD_CLK
17	U163 pin 47	Pulse train.	AD_TS
18	U165 pin 48	Pulse train.	ADSEL

Analog circuitry checks

Table 4-4 summarizes analog circuitry checks.

Table 4-4
Analog circuitry checks

Step	Item/component	Required condition*	Remarks
1	INPUT #1	Apply +20mA	Select chan 1 20mA range.
2	TP312	-10V	Chan 1 I/V converter output.
3	TP318	Pulses	Chan 1 A/D input signal(s).
4	INPUT #2	Apply +20mA	Select chan 2 20mA range.
5	TP512	-10V	Chan. 2 I/V converter output.
6	TP518	Pulses	Chan 2 A/D input signal(s).
7	Source 1	10V range, output	Set channel 1 source to +10V.
8	TP308	-2V	Ch. 1 DAC output.
9	TP306, TP311	+10V	Ch. 1 source output.
10	Source 1	100V range, output	Set channel 1 source to +100V.
11	TP308	-2V	Ch. 1 DAC output.
12	TP306, TP311	+100V	Ch. 1 source output (OUTPUT ON).
13	Source 2	10V range, output	Set channel 2 source to +10V.
14	TP508	-2V	Ch. 2 DAC output.
15	TP506, TP511	+10V	Ch. 2 source output (OUTPUT ON).
16	Source 2	100V range, output	Set channel 2 source to +100V.
17	TP508	-2V	Ch. 2 DAC output.
18	TP506, TP511	+100V	Ch. 2 source output (OUTPUT ON).

*Voltage source steps (8-18) are with OUTPUT ON. Source 1 voltages reference to A_GND TP. Source 2 voltages referenced to B_GND TP.

No comm link error

A “No Comm Link” error message indicates that the front panel processor has stopped communicating with the main processor, which is located on the mother board. This error indicates that the main processor ROMs may require reseating in their sockets. The ROMs may be reseated as follows:

1. Turn off the power, and disconnect the line cord and all other test leads and cables from the instrument.
2. Remove the case cover as outlined in Section 5.
3. Locate the firmware ROMs located on the digital section of the mother board. These ROMs are the only IC installed in a socket. (Refer to the 2500-100 component layout drawing at the end of Section 6 for exact location.)

CAUTION **Be careful not to push down excessively, or you might crack the mother board.**

4. Carefully push down on the ROM ICs to make sure it is properly seated in its socket.
5. Connect the line cord, and turn on the power. If the problem persists, additional troubleshooting will be required.

5
Disassembly

Introduction

This section explains how to handle, clean, and disassemble the Model 2500 Dual Photodiode Meter. Disassembly drawings are located at the end of this section.

Handling and cleaning

To avoid contaminating PC board traces with body oil or other foreign matter, avoid touching the PC board traces while you are repairing the instrument. The preamp boards and certain mother board areas have high-impedance devices or sensitive circuitry where contamination could cause degraded performance.

Handling PC boards

Observe the following precautions when handling PC boards:

- Wear cotton gloves.
- Only handle PC boards by the edges and shields.
- Do not touch any board traces or components not associated with repair.
- Do not touch areas adjacent to electrical contacts.
- Use dry nitrogen gas to clean dust off PC boards.

Solder repairs

Observe the following precautions when you must solder a circuit board:

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work area when you have finished the repair by using pure water with clean, foam-tipped swabs or a clean, soft brush.
- Once you have removed the flux, swab only the repair area with methanol, then blow-dry the board with dry nitrogen gas.
- After cleaning, allow the board to dry in a 122°F (50°C), low-humidity environment for several hours.

Static sensitive devices

CAUTION **Many CMOS devices are installed in the Model 2500. Handle all semiconductor devices as being static sensitive.**

CMOS devices operate at very high impedance levels. Therefore, any static that builds up on you or your clothing may be sufficient to destroy these devices if they are not handled properly. Use the following precautions to avoid damaging them:

- Transport and handle ICs only in containers specially designed to prevent static build-up. Typically, you will receive these parts in anti-static containers made of plastic or foam. Keep these devices in their original containers until ready for installation.
- Remove the devices from their protective containers only at a properly grounded work station. Ground yourself with a suitable wrist strap.
- Handle the devices only by the body; do not touch the pins.
- Ground any printed circuit board into which a semiconductor device is to be inserted to the bench or table.
- Use only anti-static type desoldering tools.
- Use only grounded-tip solder irons.
- Once the device is installed in the PC board, it is normally adequately protected, and you can handle the boards normally.

Assembly drawings

Use the assembly drawings located at the end of this section to assist you as you disassemble and reassemble the Model 2500. Refer to these drawings for information about the Keithley part numbers of most mechanical parts in the unit. Assembly drawings include:

- Front panel assembly — 2500-040
- Chassis/power module assembly — 2500-050
- Front panel/chassis assembly — 2500-051
- Chassis assembly — 2500-052
- Final inspection — 2500-080

Case cover removal

WARNING **Before removing the case cover, disconnect the line cord and any test leads from the instrument.**

Follow the steps below to remove the case cover to gain access to internal parts.

1. **Remove handle** — The handle serves as an adjustable tilt-bail. Adjust its position by gently pulling it away from the sides of the instrument case and swinging it up or down. To remove the handle, swing the handle below the bottom surface of the case and back until the orientation arrows on the handles line up with the orientation arrows on the mounting ears. With the arrows lined up, pull the ends of the handle away from the case.
2. **Remove mounting ears** — Remove the screw that secures each mounting ear. Pull down and out on each mounting ear.

NOTE *When reinstalling the mounting ears, make sure to mount the right ear to the right side of the chassis, and the left ear to the left side of the chassis. Each ear is marked RIGHT or LEFT on its inside surface.*

3. **Remove rear bezel** — To remove the rear bezel, loosen the two screws that secure the rear bezel to the chassis, then pull the bezel away from the case.
4. **Remove bottom screws** — Remove the four screws that secure the case to the chassis. They are located on the bottom of the case.
5. **Remove chassis** — To remove the case, grasp the front bezel of the instrument, and carefully slide the chassis forward. Slide the chassis out of the metal case.

Input board removal

Perform the following steps to remove the two input boards. This procedure assumes that the case cover is already removed.

1. Remove the INPUT jack nuts.

   Each INPUT jack has a nut that secures the jack to the rear panel. Remove these two nuts and lock washers.
2. Remove input board bracket mounting screws.

   Remove the two mounting screws that secure the input board support bracket to the chassis.

3. Unplug cables:
   - Unplug the connecting cable at the rear of each input board.
   - Disconnect the input board connecting cables from the mother board at J301 and J501.
4. Remove input board assembly.

   Slide the input board assembly forward until the INPUT jacks clear the mounting holes in the rear panel, then remove the assembly.

Mother board removal

Perform the following steps to remove the mother board. This procedure assumes that the case cover and input boards are already removed.

1. Remove the IEEE-488, DIGITAL I/O, and RS-232 fasteners.

   The IEEE-488, DIGITAL I/O, and RS-232 connectors each have two hex head screws that secure the connectors to the rear panel. Remove these screws.
2. Remove mother board mounting screws.

   Remove the four mounting screws that secure the mother board to the chassis.
3. Unplug cables:
   - Unplug the display board ribbon cable from J1014.
   - Unplug the cable going to the power supply module from J104.
   - Unplug the cables going to the power transformers from J305 and J505.
   - Unplug the cable going to the OUTPUT indicator from J105.
   - Unplug the wires going to the rear panel VOLTAGE SOURCE OUTPUT jacks from J302 and J502.
4. Remove mother board.

   Slide the mother board forward slightly until the rear panel connectors clear the holes in the rear panel, then remove the board.

   During reassembly, replace the mother board, and start the IEEE-488, DIGITAL I/O, and RS-232 connector screws and the board mounting screws. Tighten all the fasteners once they are all in place and the board is correctly aligned. Be sure to plug in all cables.

Front panel disassembly

Use the following procedure to remove the display board and/or the pushbutton switch pad.

1. Remove the power switch rod. Carefully disconnect the power switch rod from the power switch mounted on the rear panel power module. Slide the rod toward the rear until it clears the access hole in the front panel, then remove the rod.
2. Remove the front panel assembly. This assembly has four retaining clips that snap onto the chassis over four pem nut studs. Two retaining clips are located on each side of the front panel. Pull the retaining clips outward and, at the same time, pull the front panel assembly forward until it separates from the chassis.
3. Unplug the display board ribbon cables.
4. Using a thin-bladed screw driver, pry the plastic PC board stop (located at the bottom of the display board) until the bar separates from the casing. Pull the display board from the front panel.
5. Remove the switch pad by pulling it from the front panel.

Removing power components

The following procedures to remove the power supply and/or power module require that the case cover and mother board be removed, as previously explained.

Power supply module removal

Perform the following steps to remove the power supply module:

1. Disconnect and remove the cables that connect the power supply module on the bottom of the chassis to the power transformer and rear panel power module.
2. Remove the screws that secure the power supply to the chassis bottom, then remove the module.

Power module removal

Perform the following steps to remove the rear panel power module:

1. Disconnect the power module's ground wire. This green and yellow wire connects to a threaded stud on the chassis with a kep nut.
2. Squeeze the latches on either side of the power module while pushing the module from the access hole.

Power transformer removal

To remove the power transformers, simply remove the screws that secure the transformers to the bottom of the chassis, then remove the transformers.

Instrument reassembly

WARNING **To ensure continued protection against electrical shock, verify that power line ground (green and yellow wire attached to the power module) is connected to the chassis. Make sure the ground wires are attached to the power transformer mounting screws.**

Make sure the four bottom case screws are properly installed to secure and ground the case cover to the chassis.

Reassemble the instrument by reversing the previous disassembly procedures. Make sure that all parts are properly seated and secured, and that all connections are properly made.

6
Replaceable Parts

Introduction

This section contains replacement parts information and component layout drawings for the Model 2500 Dual Photodiode Meter.

Parts lists

The electrical parts lists for the Model 2500 are listed in the tables at the end of this section. For part numbers to the various mechanical parts and assemblies, use the Miscellaneous parts list and the assembly drawings provided at the end of Section 5.

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 2500)
- Instrument serial number
- Part description
- Component designation (if applicable)
- Keithley part number

Factory service

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

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

Component layouts

The component layouts for the circuit boards are provided on the following pages. Drawings include:

- Mother board — 2500-100
- Display board — 2400-110
- Input board — 2500-120
- Power board — 2500-130

Table 6-1
Mother board parts list

Circuit designation	Description	Keithley part no.
C217,C218,C266,C384,C584	CAP, 1000PF, 10%, 50V, MONO CERAMIC	C-452-1000P
C219,C221,C222,C227,C233,C234,C238-C241	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C220,C225,C226,C229-C232,C235,C242,C245	CAP, .01UF, 10%, 50V, CERAMIC	C-491-.01
C223	CAP, 47PF, 10%, 100V, CERAMIC	C-451-47P
C224,C228	CAP, 15P, 1%, 100V, CERAMIC	C-512-15P
C236,C304,C309,C313,C386,C402,C405,C504	CAP, 22UF, 20%, 25V, TANTALUM	C-440-22
C237,C385,C585,C400,C401,C403,C404,C600	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C243,C246,C253,C255-C258,C262-C264,C267	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C251,C311,C312,C511,C512	CAP, 1UF, 20%, 50V, CERAMIC	C-519-1
C259,C268,C371,C373,C381,C392,C399,C599	CAP, 47P, 5%, 100V, CERAMIC	C-465-47P
C265	CAP, 100P, 10%, 100V, CERAMIC	C-451-100P
C279	CAP, .1UF, 20%, 100V, CERAMIC	C-436-.1
C280,C283-C289,C291,C293,C294,C301-C303	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C282	CAP, .01UF, 10%, 50V, CERAMIC	C-491-.01
C290	CAP, 1UF, 20%, 35V, TANTALUM	C-494-1
C292	CAP, 100P, 10%, 100V, CERAMIC	C-451-100P
C305-C307,C310,C314,C320,C321,C331,C332	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C308,C317,C319,C508,C517,C519	CAP, 1000UF, 20%, 35V, ALUM ELEC	C-468-1000
C323,C324,C356,C357,C364,C408,C409,C411	CAP, 1UF, 10%, 500V, X7R	C-525-.1
C325,C326,C525,C526	CAP, 220U, 20%, 160V, ALUM	C-584-220
C342,C343,C346,C349-C355,C358,C363	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C344,C359,C362,C544,C559,C562	CAP, 10UF, 20%, 25V, TANTALUM	C-440-10
C345,C545,C328,C365,C528,C565	CAP, 100PF, 5%, 100V, CERAMIC	C-465-100P
C360,C560	CAP, 100P, 5%, 500V, CERAMIC	C-590-100P
C366,C372,C374-C379,C391,C393,C395	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C367,C567,C347,C348,C369,C547,C548,C569	CAP, 1UF, 10%, 500V, X7R	C-525-.1
C380,C383,C580,C583	CAP, 2200P, 10%, 100V, CERAMIC	C-430-2200P
C382,C582	CAP, 100PF, 5%, 100V, CERAMIC	C-465-100P
C388,C588	CAP, .1UF, 20%, 50V, CERAMIC	C-418-.1

Table 6-1 (cont.)
Mother board parts list

Circuit designation	Description	Keithley part no.
C394,C396,C594,C596	CAP, .01UF, 10%, 50V, CERAMIC	C-491-.01
C397,C597	CAP, 47P, 5%, 100V, CERAMIC	C-465-47P
C398,C598	CAP, 100UF, 20%, 16V, TANTALUM	C-504-100
C406,C407,C606,C607	CAP, 100UF, ±20%, 200V, ALUM ELECT	C-498-100
C412,C413,C612,C613	CAP, 47U, +50%, -20%, 160V, ALUM ELEC	C-354-47
C414,C415,C418,C419,C614,C615,C618,C619	CAP, 2.2UF, ±20%, 200V, ALUM ELECT	C-498-2.2
C416,C417,C616,C617	CAP, .01UF, 10%, 200V, CERAMIC	C-472-.01
C501-C503,C505-C507,C510,C514,C520,C521	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C509,C513,C586,C602,C605	CAP, 22UF, 20%, 25V, TANTALUM	C-440-22
C523,C524,C556,C557,C564,C608,C609,C611	CAP, 1UF, 10%, 500V, X7R	C-525-.1
C531,C532,C542,C543,C546,C549-C555,C558	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C563,C566,C572,C574-C579,C591,C593	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C570	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C571,C573,C581,C592	CAP, 47P, 5%, 100V, CERAMIC	C-465-47P
C587,C589,C590,C387,C389,C390	CAP, .1UF, 20%, 50V, CERAMIC	C-418-.1
C595,C318,C322,C327,C370,C518,C522,C527	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C601,C603,C604,C281,C315,C316,C515,C516	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
CR115,CR116,CR122-CR129	DIODE, DUAL SWITCHING, BAV99L	RF-82
CR117,CR118,CR119,CR120,CR121	DIODE, DUAL COMMON ANODE BAW56LT2	RF-98
CR302,CR502,CR303,CR503	ULTRA FAST BRIDGE RECTIFIER, EDF1BM	RF-123
CR304,CR504	DIODE, CRB2-100	RF-148
CR309-CR312,CR314-CR319,CR509-CR512	DIODE, SWITCHING, MMBD914	RF-83
CR313,CR513	DIODE, DUAL HSM-2822T31	RF-95
CR514-CR519	DIODE, SWITCHING, MMBD914	RF-83
F101	POLYSWITCH, SMD030-2	FU-103
HS301-HS303,HS501-HS503	HEAT SINK	HS-55
HS314,HS514	HEAT SINK	HS-39
J1006	CONN, CIRCULAR DIN	CS-762
J1007	CONN, D-SUB DUAL STACK M-F	CS-1072-1
J1008	CONN, RIGHT ANGLE, 24 PIN	CS-501
J101,J103	CONN, BERG	CS-339
J1014	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-16
J102	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-10
J104	CONNECTOR, HEADER	CS-784-4
J105,J302,J502	LATCHING HEADER, FRICTON, SGL ROW	CS-724-3

Table 6-1 (cont.)
Mother board parts list

Circuit designation	Description	Keithley part no.
J301,J305,J501,J505	LATCHING HEADER, FRICTION, SINGLE ROW	CS-724-12
K306,K506	RELAY, SURFACE MOUNT	RL-188
K307,K308,K507,K508	NON LATCHING RELAY	RL-242
L101	FERRITE BEAD	CH-91
L102,L304-L308,L504-L508,L310,L510	FERRITE CHIP 600 OHM BLM32A07	CH-62
L301-L303,L501-L503,L309,L509,L311,L511	FERRITE CHIP 600 OHM BLM32A07	CH-62
Q118,Q120-Q125,Q309,Q310,Q321-Q324,Q509	TRANS, N-MOSFET, VN0605T	TG-243
Q312,Q330,Q512,Q530,Q316,Q516	TRANS, NPN, CXTA42	TG-327
Q313,Q513	TRANS, NPN, MMBT3904	TG-238
Q314,Q514	TRANS, PMP, MJE5731A (TO-220)	TG-315
Q315,Q327,Q515,Q527,Q311,Q511	TRANS, PNP, CXTA92	TG-328
Q318,Q518	TRANS, NPN, TIP48 (TO-220)	TG-314
Q319,Q320,Q325,Q328,Q519,Q520,Q525,Q528	TRANS, NPN, MMBT3904	TG-238
Q326,Q329,Q526,Q529	TRANS, PNP, MMBT3906L	TG-244
Q510,Q521-Q524	TRANS, N-MOSFET, VN0605T	TG-243
R205	RES, .0499, 1%, 100MW, THICK FILM	R-418-.0499
R206,R209,R219,R220,R222,R235,R236,R216	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R210,R211,R221,R228,R230,R231,R267,R272	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R213,R215,R217,R237,R232-R234,R372,R384	RES, 475, 1%, 100MW, THICK FILM	R-418-475
R226,R227,R293,R295,R297,R299,R378,R578	RES, 5.11K, 1%, 100MW, THICK FILM	R-418-5.11K
R229,R239,R278,R294,R296,R298,R304,R381	RES, 100, 1%, 100MW, THICK FILM	R-418-100
R238	RES, 15k, 1%, 100MW, THICK FILM	R-418-15K
R240	RES, 332K, 1%, 100MW, THICK FILM	R-418-332K
R241-R244,R249-R251,R253,R263-R266,R268	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R245,R246	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R247,R248	RES, 2K, 1%, 100MW, THICK FILM	R-418-2K
R252	RES, 10M, 1%, 125MW, THICK FILM	R-418-10M
R254,R270	RES, 4.75K, 1%, 100MW, THICK FILM	R-418-4.75K
R255-R257,R279,R284,R367,R368,R567,R568	RES, 2.21K, 1%, 100MW, THICK FILM	R-418-2.21K
R258-R262,R376,R576	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R269,R271,R274-R276,R285-R290,R369,R218	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R273	RES, 100, 5%, 250MW, METAL FILM	R-376-100
R280,R281,R291,R292,R323,R328,R329,R344	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R282	RES, 475, 1%, 100MW, THICK FILM	R-418-475
R317,R424,R517,R624	RES, 1K, 1%, 100MW, THIN FILM	R-438-1K
R322,R522	RES, 110K, 1%, 100MW, THICK FILM	R-418-110K
R324,R524	RES, 48.1K, .1%, 1/10W, METAL FILM	R-263-48.1K
R325,R525	RES, 5.62K, .1%, 1/10W, METAL FILM	R-263-5.62K
R326,R526	RES, 392, 1%, 100MW, THICK FILM	R-418-392
R327,R330,R333,R335,R527,R530,R533,R535	RES, 69.8K, 1%, 1W, THICK FILM	R-418-69.8K

Table 6-1 (cont.)
Mother board parts list

Circuit designation	Description	Keithley part no.
R332,R334,R532,R532	RES, 4.75M, 1%, 100MW, THICK FILM	R-418-4.75M
R336,R339,R536,R539	RES, 10, 10%, 100MW, THICK FILM	R-418-10
R342,R343,R345,R346,R542,R543,R545,R546	RES, 20K, 5%, 250MW, METAL FILM	R-376-20K
R349,R549,R425,R625	RES, 100K, .1%, 1/10W, METAL FILM	R-263-100K
R351,R355,R389,R395,R551,R555,R589,R595	RES, 100K, 1%, 100MW, THICK FILM	R-418-100K
R356,R357,R523,R528,R529,R544,R556,R557	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R358-R365,R558-R565	RES, 4.99K, 1%, 100MW, THICK FILM	R-418-4.99K
R366,R566	RES, 1.28M, .1%, 1/8W, METAL FILM	R-176-1.28M
R370,R570	RES, 49.9K, 1%, 100MW, THICK FILM	R-418-49.9K
R371,R383,R398,R569,R571,R583,R598	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R373,R573	RES, 34K, 1%, 100MW, THICK FILM	R-418-34K
R374,R574	RES, 82.5, 1%, 100MW, THICK FILM	R-418-82.5
R375,R575	RES, 4.75K, 1%, 100MW, THICK FILM	R-418-4.75K
R377,R577	RES, 100, 1%, 100MW, THICK FILM	R-418-100
R379,R579	RES, 470, 5%, 125MW, METAL FILM	R-375-470
R380,R580	RES, 10, 5%, 125MW, METAL FILM	R-375-10
R382,R392,R582,R592	RES, .0499, 1%, 100MW, THICK FILM	R-418-.0499
R385,R386,R585,R586	RES, 6.04K, 1%, 100MW, THICK FILM	R-418-6.04K
R387,R587	RES, 2.49K, 1%, 125MW, METAL FILM	R-391-2.49K
R388,R588	RES, 4.99K, 1%, 125MW, METAL FILM	R-391-4.99K
R390,R590	RES, 6.04K, 1%, 125MW, THIN FILM	R-423-6.04K
R391,R591	RES NET	TF-245
R396,R399,R596,R599,R319,R320,R519,R520	RES, 24.9, 1%, 100MW, THICK FILM	R-418-24.9
R397,R409,R410,R597,R609,R610	RES, 10, 5%, 250MW, METAL FILM	R-376-10
R401,R601	RES, 909, 1%, 1W, THICK FILM	R-418-909
R403,R603	RES, 100K, 1%, .1W, THIN FILM	R-438-100K
R405-R408,R572,R584,R605-R608,R207,R208	RES, 475, 1%, 100MW, THICK FILM	R-418-475
R411,R415,R611,R615	RES, 1K, 5%, 250MW, METAL FILM	R-376-1K
R412,R413,R416,R417,R612,R613,R616,R617	RES, 20K, 5%, 250MW, METAL FILM	R-376-20K
R414,R418,R614,R618	RES, 11K, 5%, 250MW, METAL FILM	R-376-11K
R419,R619	RES, 20K, 1%, 100MW, THIN FILM	R-438-20K
R420,R620	RES, 2.21K, 1%, 100MW, THIN FILM	R-438-2.21K
R423,R623	RES, 11.8K, 1%, 100MW, THIN FILM	R-438-11.8K
R426-R430,R626-R630	RES, 174K, 1%, 100MW, THIN FILM	R-438-174K
R540,R541,R547,R548,R318,R422,R518,R622	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R581	RES, 100, 1%, 100MW, THICK FILM	R-418-100
R594,R394,R331,R340,R341,R347,R348,R531	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
RV301,RV501	VARISTOR SMT	VR-27
RV302,RV502	VARISTOR	VR-23
SA301,SA501	SURGE ARRESTOR CG2-300L	SA-2
SO120,SO121	SOCKET PLCC-032-T-A	SO-143-32

Table 6-1 (cont.)
Mother board parts list

Circuit designation	Description	Keithley part no.
U120	PROGRAMMED ROM	2500-800*
U121	PROGRAMMED ROM	2500-801*
U150	64K BIT SERIAL FRAM	IC-1381
U154,U161	IC, 2 INPUT NAND GATE, NC7S00	IC-1181
U155	IC, OCT BFR/LINE DRIVE, 74HCT244	IC-651
U159,U165	IC, POS NAND GATES/INVERT, 74HCT14	IC-656
U160,U162	IC, 256K X 16 BIT CMOS RAM 17NS	LSI-249-1
U163	IC, 32-BIT MICROCONTROLLER 20MHZ	LSI-203-20
U164	IC, PROTECTED QUAD POWER DRIVERS	IC-1212
U166	IC, +5V RS-232 TRANSCEIVER, MAX202	IC-952
U167	IC, GPIB ADAPTER, 9914A	LSI-123
U169	IC, OCTAL INTER BUS TRANS, 75161	IC-647
U170	IC, OCTAL INTERFACE BUS, 75160	IC-646
U171	IC, 2-INPUT OR GATE	IC-1206
U301,U501	IC, +5V VOLTAGE REGULATOR, LM2940CT	IC-576
U302,U502	IC, POS VOLTAGE REG +15V, 60MA, LM2940CT-15	IC-1186
U303,U503	IC, NEG VOLTAGE REG -15V, 50MA, LM2990T-15	IC-1187
U304,U305,U504,U505	IC, OPTOCOUPLER, 2611	IC-690
U308,U508	IC, CMOS ANALOG SWITCH	IC-1395
U309,U509	IC, +5V 16 BIT DAC, MAX542ACSD	IC-1176
U310,U510	IC, VOLTAGE REFERENCE	IC-1065
U312,U512	IC, DIFFERENTIAL AMP, INA117P	IC-889
U313,U513	IC, DUAL OP-AMP, LF353M	IC-842
U314,U514	IC, OP AMP, LOW POWER AD795JR	IC-1052
U315,U316,U515,U516	IC, 8 STAGE SHIFT C074HC409AM	IC-1026
U317,U517	IC, 8-CHAN ANA MULTIPLEXER, DG408DY	IC-844
U318,U518	IC, OP-AMP, LOW NOISE LT1007CS8	IC-949
U319,U519	IC, QUAD D FLIP FLOP W/CLK, RESET 74HC175	IC-923
U320,U321,U520,U521	IC, QUAD 2 IN NOR, 74HCT02	IC-809
U322,U522	IC, NCHAN LAT DMOS QUADFET, SD5400CY	IC-893
U323,U523,U311,U511	IC, OPA177GS	IC-960

Table 6-1 (cont.)
Mother board parts list

Circuit designation	Description	Keithley part no.
U324,U524	IC, PRECISION BIFET OPAMP	IC-1194
U325,U525	IC, OP-AMP, NE5534D	IC-802
U326,U526	IC, VOLT. COMPARATOR, LM311M	IC-776
U327,U527	PROGRAM	2000-802*
U328,U528	IC, DUAL BIPOLAR OP-AMP, LT1124CS8	IC-955
U329,U529	IC, +5V 12 BIT DAC	IC-1329
U330,U530	IC, SUPPLY VOLT SUPERVISOR, TL7705A	IC-860
U331,U531	IC, VOLTAGE REGULATOR	IC-1132
U332,U532	IC, -5V VOLTAGE REGULATOR	IC-1134
U334,U534,U333,U533	IC, DUAL HIGH CMR/SPEED OPTO, HCPL-2631	IC-588
VR101	DIODE, ZENER 30V BZX84C30	DZ-106-30
VR303,VR304,VR503,VR504	DIODE, ZENER MM524694 TI	DZ-113
VR308,VR309,VR508,VR509	DIODE, ZENER, 6.2V MMSZ6V2	DZ-97
VR310,VR510	DIODE	DZ-127
Y101	CRYSTAL, FSM327	CR-41
Y301,Y501	OSCILLATOR HIGH SPEED CMOS 12MHZ	CR-37

*Order current firmware revision. For example, 2500-801A01.

Table 6-2
Input board parts list

Circuit designation	Description	Keithley part no.
C327	CAP, .01UF, 10%, 200V, CERAMIC	C-472-.01
C328,C337	CAP, 1000P, 10%, 100V, CERAMIC	C-451-1000P
C329	CAP, 33PF, 10%, 100V, CERAMIC	C-451-33P
C330	CAP, 10PF, 5%, 100V, CERAMIC	C-372-10P
C333,C336,C338,C341	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C334,C335	CAP, .33U, 10%, 16V, TANTALUM	C-585-3.3
C339,C340	CAP, 10UF, 20%, 25V, TANTALUM	C-440-10
C342	CAP, 100PF, 5%, 100V, CERAMIC	C-465-100P
C345	CAP, 47P, 5%, 100V, CERAMIC	C-465-47P
CR305,CR306,CR307,CR308,CR309, CR310	DIODE, SWITCHING, MMBD914	RF-83
J100	CONN, MALE 12 PIN RT ANGLE	CS-612-12
J303	TRIAX RECEPTACLE, PCB MOUNT	CS-995
K301	RELAY, 1FORMA, COTO 1203-0147	RL-181
K302,K303,K304,K305	RELAY, SURFACE MOUNT	RL-188
Q301,Q302	TRANS, N-MOSFET, VN0605T	TG-243
Q305,Q306	TRANS, N CHANNEL FET, 2N4392	TG-128-1
R300,R301,R302,R303	RES, 500, .1%, 1/10W, METAL FILM	R-263-500
R308	RES, 50K, .1%, 1/10W, METAL FILM	R-263-50K
R310,R315,R316	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R312	RES, 5M, 1%, 1W, METAL FILM	R-502-5M
R313	RES, 500M, 1%, 1W, METAL FILM	R-502-500M
R314,R305,R306,R311	RES, 392, 1%, 100MW, THICK FILM	R-418-392
R317,R404,R406,R405	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R318,R323	RES, 24.9K, 1%, 100MW, THICK FILM	R-418-24.9K
R319	RES, 71.5K, 1%, .1W, THIN FILM	R-438-71.5K
R320	RES, 150, 1%, 100MV, THIN FILM 0805	R-438-150
R321	RES, 1.37K, 1%, .1W, THICK FILM	R-418-1.37K
R407	RES, 100, 1%, 100MW, THICK FILM	R-418-100
TP305,TP306	SURFACE MOUNT PCB TEST POINT	CS-1026
U303,U304,U305	IC, CMOS ANALOG SWITCH	IC-1395
U306	IC, 25 FEMTO-AMP ELECTRO AMP LMC6001AIN	IC-1207
U307	IC, OP-AMP, NE5534D	IC-802
VR301,VR302	DIODE, ZENER 10V, MMSZ5240B	DZ-99

Table 6-3
Power board parts list

Circuit designation	Description	Keithley part no.
J1001,J1002,J1003,J1004	CONN, RT ANGLE, MALE MOLEX, .156	CS-715-6
RV101	VARISTOR	VR-26

Table 6-4
Display board parts list

Circuit designation	Description	Keithley part no.
C901	CAP, 22UF, 20%, 6.3, TANTALUM	C-417-22
C902,C904,C907,C908,C910	CAP, .1UF, 20%, 100V, CERAMIC	C-436-.1
C903,C905,C906,C909,C911	CAP, .1UF, 20%, 50V, CERAMIC	C-418-.1
C912	CAP, 2.2UF, 20%, 100V, ALUM ELEC	C-503-2.2
C913,C914	CAP, 100UF, 20%, 16V, TANTALUM	C-504-100
C915,C916	CAP, 33PF, 10%, 100V, CERAMIC	C-451-33P
CR901,CR902,CR903,CR904	DIODE, SWITCHING, 250MA, BAV103	RF-89
CR905,CR906	DIODE, SWITCHING, MMBD914	RF-83
DS901	VACUUM FLUORESCENT DISPLAY	DD-51C
J1032	CONN, BERG	CS-339
J1033	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-16
Q901,Q902	TRANS, NPN GEN PURPOSE, BC868	TG-293
R901	RES NET, 15K, 2%, 1.875W	TF-219-15K
R902	RES, 13K, 5%, 125MW, METAL FILM	R-375-13K
R903,R904	RES, 4.7K, 5%, 250MW, METAL FILM	R-376-4.7K
R905	RES, 1M, 5%, 125MW, METAL FILM	R-375-1M
R906	RES, 1K, 5%, 250MW, METAL FILM	R-376-1K
R907	RES, 240, 5%, 250MW, METAL FILM	R-376-240
R908	RES, 10M, 5%, 125MW, METAL FILM	R-375-10M
T901	TRANSFORMER, TDK, ER14.5 SERIES	TR-300
U901,U904,U905	IC, LATCHED DRIVERS, UCN-5812EPF-1	IC-732
U902	PROGRAMMED ROM	7001-800A02
U903	IC, 32-BIT, SERIAL UCN5818EPF-1	IC-830
VR901	DIODE, ZENER, 8.2V, MMBZ5237	DZ-92
Y901	CRYSTAL, 4MHZ	CR-36-4M

Table 6-5
Miscellaneous parts list

Qty	Description	Keithley part no.
2	BANANA JACK, PUSH-IN RED	BJ-14-2
1	BEZEL, REAR	428-303D
1	CABLE ASSEMBLY	CA-239-1A
1	CONDUCTIVE RUBBER SWITCH	2500-315A
1	COVER	2500-317A
1	DISPLAY LENS	2500-311A
2	FOOT	428-319A
2	FOOT, EXTRUDED	FE-22A
2	FOOT, RUBBER	FE-6
1	FRONT PANEL, MODIFIED	2400-318B
1	FUSE HOLDER	FH-35-1
1	FUSE, .630A, 250V, SLO BLO FUSE	FU-106-.630
1	HANDLE	428-329F
1	LABEL	MC-233A
1	LED, HIGH POWER	PL-94
1	LENS, LED	6517-309B
1	LINE CORD	CO-7
1	LINE MODULE	PM-1-1B
1	MEMBRANE SWITCH, FRONT PANEL	6430-313A
1	MOUNTING EAR, LEFT	428-338B
1	MOUNTING EAR, RIGHT	428-328E
2	PC BOARD STOP	2001-371A
1	POWER ROD	2001-320A
1	POWER SUPPLY	PS-75-1A
1	SUPPORT BAR	2500-318A
2	TRANSFORMER	TR-342B

A
Specifications

The Model 2500 Dual Photodiode Meter can measure and display either photodiode current or optical power for two photodiodes with appropriate user-supplied optical power gain/wavelength calibration factors.

Measurement Specifications

RANGE	MAXIMUM RESOLUTION	ACCURACY[1,2] 23°C ±5°C ±(% rdg. + offset)	TEMPERATURE COEFFICIENT 0°–18°C & 28°–50°C ±(%rdg. + offset)/°C	DC INPUT IMPEDANCE[3] (Maximum)
2.000000 nA	1 fA	1.00% + 2 pA	0.01 + 200 fA	20 kΩ
20.00000 nA	10 fA	0.40% + 2 pA	0.01 + 200 fA	20 kΩ
200.0000 nA	100 fA	0.30% + 200 pA	0.02 + 20 pA	200 Ω
2.000000 µA	1 pA	0.20% + 200 pA	0.02 + 20 pA	200 Ω
20.00000 µA	10 pA	0.10% + 20 nA	0.01 + 2 nA	2.0 Ω
200.0000 µA	100 pA	0.10% + 20 nA	0.01 + 2 nA	2.0 Ω
2.000000 mA	1 nA	0.10% + 2 µA	0.02 + 200 nA	0.2 Ω
20.00000 mA	10 nA	0.10% + 2 µA	0.02 + 200 nA	0.2 Ω

MAXIMUM INPUT: ±20.0mA.

Typical Speed and Noise Rejection[4]

DIGITS	READINGS/s GPIB (SCPI)	GPIB (488.1)	NPLC	NMRR
4½	700	900	0.01	—
5½	460	475	0.1	—
6½	58	58	1	60 dB

Photodiode Voltage Bias Specifications[2]

RANGE	RESOLUTION	ACCURACY 23°C ±5°C	MAXIMUM CURRENT	LOAD REGULATION[5]	TEMPERATURE COEFFICIENT
0 to ±10 V	<400 µV	±(0.15% of setting + 5 mV)	20 mA	< 0.30%, 0 to 20 mA	150 ppm/°C
0 to ±100 V	<4 mV	±(0.3% of setting + 50 mV)	20 mA	< 0.30%, 0 to 20 mA	300 ppm/°C

General

Typical Noise Floor Measurement Specification[6]

RANGE	TYPICAL NOISE FLOOR RMS (1 STDEV), 100 SAMPLES 0.01 NPLC	0.1 NPLC	1.0 NPLC	10 NPLC
2.000000 nA	2 pA	1 pA	40 fA	15 fA
20.00000 nA	2 pA	1 pA	40 fA	15 fA
200.0000 nA	200 pA	100 pA	2 pA	500 fA
2.000000 µA	200 pA	100 pA	2 pA	500 fA
20.00000 µA	20 nA	10 nA	200 pA	50 pA
200.0000 µA	20 nA	10 nA	200 pA	50 pA
2.000000 mA	2 µA	1 µA	25 nA	5 nA
20.00000 mA	2 µA	1 µA	25 nA	5 nA

SOURCE CAPACITANCE: Stable to 10.0nF typical.

INPUT BIAS CURRENT[7]: 50fA max. @ 23°C.

INPUT VOLTAGE BURDEN[8]: 4.0mV max.

VOLTAGE SOURCE SLEW RATE: 3.0ms/V typical.

COMMON MODE VOLTAGE: 200VDC.

COMMON MODE ISOLATION: Typically $10^9\Omega$ in parallel with 150nF.

OVERRANGE: 105% of measurement range.

MEMORY BUFFER: 6000 readings (two 3000 point buffers). Includes selected measured value(s) and time stamp.

PROGRAMMABILITY: IEEE-488 (SCPI-1995.0), RS-232, five user-definable power-up states plus factory default and *RST.

DIGITAL INTERFACE:
Enable: Active low input.
Handler Interface: Start of test, end of test, 3 category bits. +5V @ 300mA supply.
Digital I/O: 1 trigger input, 4 TTL/Relay Drive outputs (33V @ 500mA, diode clamped).

POWER SUPPLY: 100V/120V/220V/240V ±10%

LINE FREQUENCY: 50, 60Hz.

POWER DISSIPATION: 60VA.

WARRANTY: 1 year.

EMC: Complies with European Union Directive 89/336/EEC.

VIBRATION: MIL-T-28800F Random Class 3.

SAFETY: Complies with European Directive 73/23/EEC.

WARM-UP: 1 hour to rated accuracy.

DIMENSIONS: 89mm high × 213mm wide × 370mm deep (3½ in × 8⅜ in × 14⁹⁄₁₆ in). **Bench configuration (with handle and feet):** 104mm high × 238mm wide × 370mm deep (4⅛ in × 9⅜ in × 14⁹⁄₁₆ in).

WEIGHT: 23.1kg (10.5 lbs).

ENVIRONMENT: Operating: 0°–50°C, 70% R.H. up to 35°C non-condensing. Derate 3% R.H./°C, 35°–50°C. **Storage:** –25° to 65°C, non-condensing.

NOTES:
1. Speed = Normal (1.0 NPLC), Filter On.
2. 1 year.
3. Measured as $\Delta V_{in}/\Delta I_{in}$ at full scale (and zero) input currents.
4. Dual channel, internal trigger, measure only, display off, Autorange off, Auto Zero off, source delay = 0, filters off, limits off, CALC5 and CALC6 off, 60Hz.
5. Measured as $\Delta V_{in}/\Delta I_{in}$ at full scale (20mA) and zero load currents.
6. Noise floor measured as rms (1 standard deviation), 100 samples, Filter off, open (capped) input.
7. Specification by design.
8. Measured (at input triax) as ΔV_{in} at full scale (20mA) vs. zero input currents.

Specifications subject to change without notice.

Accuracy calculations

The following information discusses how to calculate accuracy for both current measurement and voltage bias functions.

Current measurement accuracy

Current measurement accuracy is calculated as follows:

Accuracy = ±(% of reading + offset)

As an example of how to calculate the actual reading limits, assume that you are measuring 1mA on the 2mA range. You can compute the reading limit range from one-year measurement specifications as follows:

Accuracy = ±(% of reading + offset)
= ±[(0.1% × 1mA) + 50nA]
= ±(1µA + 50nA)
= ±1.05µA

Thus, the actual reading range is 1mA ±1.05µA or from 0.99895mA to 1.00105mA.

Voltage bias accuracy

Voltage bias accuracy is calculated similarly, except that voltage bias specifications are used. As an example of how to calculate the actual source output limits, assume that you are sourcing 5V on the 10V range. You can compute the output limits from voltage bias one-year accuracy specifications as follows:

Accuracy = ±(0.05% of setting + 5mV offset)
= ±[(0.05% × 5V) + 5mV)]
= ±(2.5mV + 5mV)
= ±7.5mV

In this case, the actual voltage output range is 5V ±7.5mV or from 4.9925V to 5.0075V.

B
Calibration Reference

Introduction

This appendix contains detailed information on the various Model 2500 Dual Photodiode Meter remote calibration commands, calibration error messages, and methods to detect the end of each calibration step.

Section 2 of this manual covers detailed calibration procedures.

Command summary

Table B-1 summarizes Model 2500 calibration commands. These commands are covered in detail in the following paragraphs.

Table B-1
Calibration commands

Command	Description
:CALibration	Calibration subsystem.
:PROTected	Calibration commands protected by password.
:CODE '<password>'	Unlock calibration. (Default password: KI002500.)
:CODE?	Query calibration code/password.
:SENSe[1] <NRf>	Calibrate active channel 1 current measurement range.
:DATA <NRf>	Set channel 1 current measurement calibration constants.
:DATA?	Query channel 1 current measurement calibration constants.
:SOURce[1] <NRf>	Calibrate channel 1 active voltage bias range.
:DATA <NRf>	Set channel 1 voltage bias calibration constants.
:DATA?	Query channel 1 voltage bias calibration constants.
:OFFSet	Calibrate channel 1 input offset voltage.
:SENSe2 <NRf>	Calibrate active channel 2 current measurement range.
:DATA <NRf>	Set channel 2 current measurement calibration constants.
:DATA?	Query channel 2 current measurement calibration constants.
:SOURce2 <NRf>	Calibrate channel 2 active voltage bias range.
:DATA <NRf>	Set channel 2 voltage bias calibration constants.
:DATA?	Query channel 2 voltage bias calibration constants.
:OFFSet	Calibrate channel 2 input voltage offset.
:DATE <yyyy>,<mm>,<dd>	Program calibration year, month, day.
:DATE?	Query calibration date.
:NDUE <yyyy>,<mm>,<dd>	Program calibration due year, month, day.
:NDUE?	Query calibration due date.
:SAVE	Save calibration data in EEPROM.
:LOCK	Lock out calibration.
:LOCK?	Query if calibration is locked (1 = locked; 0 = unlocked).
:COUNt?	Query number of times Model 2500 has been calibrated.

Miscellaneous commands

Miscellaneous commands are those commands that perform such functions as unlocking calibration, saving calibration constants, locking out calibration, and programming date parameters.

:CODE

(:CALibration:PROTected:CODE)

Purpose To unlock calibration so that you can perform the calibration procedures.

Format
```
:cal:prot:code '<password>'
```

Parameter Up to an 8-character string including letters and numbers.

Description The :CODE command sends the password/code and enables calibration when performing these procedures via remote. The correct password must be sent to the unit before sending any other calibration command. The default remote password is KI002500.

Note

- The :CODE command should be sent only once before performing calibration. Do not send :CODE before each calibration step.
- To change the code, first send the present code, then send the new code.
- The password parameter must be enclosed in single quotes.
- If you change the first two characters of the password to something other than "KI", you will not be able to unlock calibration from the front panel.

Example
```
:CAL:PROT:CODE 'KI002500'
```
Send default code of KI002500.

:COUNT?

(:CALibration:PROTected:COUNT?)

Purpose To request the number of times the Model 2500 has been calibrated.

Format
```
:cal:prot:count?
```

Response Number of times calibrated.

Description The :COUNT? query may be used to determine the total number of times the Model 2500 has been calibrated.

Example
```
:CAL:PROT:COUNT?
```
Request calibration count.

:LOCK

(:CALibration:PROTected:LOCK)

Purpose To lock out calibration.

Format
```
:cal:prot:lock
```

Query :cal:prot:lock?

Response
0 Calibration unlocked
1 Calibration locked

Description The :LOCK command allows you to lock out calibration after completing the procedure. Thus, :LOCK performs the opposite of sending the password with the :CODE command. The :LOCK? query returns calibration lock status.

Note To unlock calibration, send the :CODE command with the appropriate password.

Example
```
:CAL:PROT:LOCK
```
Lock out calibration.

:SAVE

(:CALibration:PROTected:SAVE)

Purpose To save calibration constants in EEROM after the calibration procedure.

Format
```
:cal:prot:save
```

Description The :SAVE command stores internally calculated calibration constants derived during calibration in EEROM. EEROM is non-volatile memory, and calibration constants will be retained indefinitely once saved. Generally, :SAVE is sent after all other calibration steps (except for :LOCK).

Note Calibration will be only temporary unless the :SAVE command is sent to permanently store calibration constants. Calibration data will not be saved if calibration was not unlocked by sending the :CODE command or if invalid calibration data exists.

Example
```
:CAL:PROT:SAVE
```
Save calibration constants.

:DATE

(:CALibration:PROTected:DATE)

Purpose To program the calibration date.

Format `:cal:prot:date <year>, <month>, <day>`

Parameters <year> = 2000 to 2099
<month> = 1 to 12
<day> = 1 to 31

Query :cal:prot:date?

Response <year>, <month>, <day>

Description The :DATE command allows you to store the calibration date in instrument EEROM for future reference. You can read back the date from the instrument by using the :DATE? query, or by using the front panel CAL menu.

Note The year, month, and day parameters must be delimited by commas.

Example `:CAL:PROT:DATE 2000,11,20` Send cal date (11/20/2000).

:NDUE

(:CALibration:PROTected:NDUE)

Purpose To send the next calibration due date to the instrument.

Format `:cal:prot:ndue <year>, <month>, <day>`

Parameters <year> = 2000 to 2099
<month> = 1 to 12
<day> = 1 to 31

Query :cal:prot:ndue?

Response <year>, <month>, <day>

Description The :NDUE command allows you to store the date when calibration is next due in instrument memory. You can read back the next due date by using the :NDUE? query, or by using the front panel CAL menu.

Note The next due date parameters must be delimited by commas.

Example `:CAL:PROT:NDUE 2001,11,20` Send due date (11/20/2001).

Current measurement commands

:SENSe

(:CALibration:PROTected:SENSe[1])
(:CALibration:PROTected:SENSe2)

Purpose To calibrate the active channel 1 or channel 2 current range.

Format
```
:cal:prot:sens1 <Cal_current>
:cal:prot:sens2 <Cal_current>
```

Parameters <Cal_current> = Within ±10% of positive full-range value
0 ±0.1% of full-range value
Within ±10% of negative full-range value

Description The :CAL:PROT:SENS1 and :CAL:PROT:SENS2 commands calibrate the active range of the channel 1 or channel 2 current measurement respectively. During the calibration process, this command is sent three times for each range, once each with parameters of approximately positive full range, 0, and negative full range. The appropriate calibration current must be applied to the channel 1 or channel 2 input terminals.

Example
```
:CAL:PROT:SENS1 1.9e-3
```
Calibrate channel 1 2mA range.

:DATA

(:CALibration:PROTected:SENSe[1]:DATA)
(:CALibration:PROTected:SENSe[1]:DATA?)
(:CALibration:PROTected:SENSe2:DATA)
(:CALibration:PROTected:SENSe2:DATA?)

Purpose To set/query channel 1 or channel 2 measurement calibration constants.

Format
```
:cal:prot:sens1:data <Cal_constants>
:cal:prot:sens2:data <Cal_constants>
```

Parameters <Cal_constants> = ASCII floating point format, delimited by commas

Query
:cal:prot:sens1:data?
:cal:prot:sens2:data?

Description The :CAL:PROT:SENS1:DATA and :CAL:PROT:SENS2:DATA commands allow you to send calibration constants directly to the unit, while the :CAL:PROT:SENS1:DATA? and :CAL:PROT:SENS2:DATA? queries request calibration constants. These commands allow you to alter calibration directly without having to perform the entire calibration procedure.

Example
```
:CAL:PROT:SENS1:DATA?
```
Query channel 1 constants.

Voltage bias commands

:SOURce

(:CALibration:PROTected:SOURce[1])
(:CALibration:PROTected:SOURce2)

Purpose To calibrate the active channel 1 or channel 2 voltage bias range.

Format
```
:cal:prot:sour1 <DMM_reading>
:cal:prot:sour2 <DMM_reading>
```

Parameters <DMM_reading> = Within ±10% of positive full-range value
0 ±0.1% of full-range value
Within ±10% of negative full-range value

Description The :CAL:PROT:SOUR1 and :CAL:PROT:SOUR2 commands calibrate the active range of the channel 1 or channel 2 voltage bias source respectively. During the calibration process, this command is sent three times for each range, once each with parameters of approximately positive full range, 0, and negative full range. The voltage parameters are determined from a DMM reading.

Example
```
:CAL:PROT:SOUR2 9.9
```
Calibrate channel 2 10V range.

:DATA

(:CALibration:PROTected:SOURce[1]:DATA)
(:CALibration:PROTected:SOURce[1]:DATA?)
(:CALibration:PROTected:SOURce2:DATA)
(:CALibration:PROTected:SOURce2:DATA?)

Purpose To set/query channel 1 or channel 2 voltage bias calibration constants.

Format
```
:cal:prot:sour1:data <Cal_constants>
:cal:prot:sour2:data <Cal_constants>
```

Parameters <Cal_constants> = ASCII floating point format, delimited by commas

Query
:cal:prot:sour1:data?
:cal:prot:sour2:data?

Description The :CAL:PROT:SOUR1:DATA and :CAL:PROT:SOUR2:DATA commands allow you to send channel 1 and channel 2 calibration constants directly to the unit, while the :CAL:PROT:SOUR1:DATA? and :CAL:PROT:SOUR2:DATA? queries request channel 1 and channel 2 calibration constants. These commands allow you to alter calibration directly without having to perform the entire procedure.

Example
```
:CAL:PROT:SOUR2:DATA?
```
Query channel 2 constants.

:OFFSet

(:CALibration:PROTected:SOURce[1]:OFFSet)
(:CALibration:PROTected:SOURce2:OFFSet)

Purpose To calibrate the channel 1 or channel 2 input voltage offset.

Format
```
:cal:prot:sour1:offs
:cal:prot:sour2:offs
```

Description The :CAL:PROT:SOUR1:OFFS and :CAL:PROT:SOUR2:OFFS commands calibrate the channel 1 or channel 2 input voltage offset respectively. A triax shielding cap should be installed on the corresponding INPUT jack during these calibration steps.

Example
```
:CAL:PROT:SOUR2:OFFS
```
Calibrate channel 2 input voltage offset.

Detecting calibration errors

If an error occurs during any calibration step, the Model 2500 will generate an appropriate error message. Several methods to detect calibration errors are discussed below.

Reading the error queue

As with other Model 2500 errors, any calibration errors will be reported in the error queue. (You can read the error queue by using the :SYST:ERR? query.)

Error summary

Table B-2 summarizes calibration errors.

Table B-2
Calibration errors

Error number	Error message
+500	“Date of calibration not set”
+501	“Next date of calibration not set”
+502	“Calibration data invalid”
+509	“Not permitted with cal locked”
+510	“Not permitted with cal unlocked”
+520	“Source + gain data invalid”
+521	“Source + offset data invalid”
+522	“Source - gain data invalid”
+523	“Source - offset data invalid”
+524	“Source DAC Overflow”
+525	“Source DAC Underflow”

Status byte EAV (Error Available) bit

Whenever an error is available in the error queue, the EAV (Error Available) bit (bit 2) of the status byte will be set. Use the *STB? query to obtain the status byte, then test bit 2 to see if it is set. If the EAV bit is set, an error has occurred, and you can use the appropriate error query to read the error and at the same time clear the EAV bit in the status byte.

Generating an SRQ on error

To program the instrument to generate an IEEE-488 bus SRQ (Service Request) when an error occurs, send the following command: *SRE 4. This command will enable SRQ when the EAV bit is set. You can then read the status byte and error queue as outlined above to check for errors and to determine the exact nature of the error.

Detecting calibration step completion

When sending remote calibration commands, you must wait until the instrument completes the current operation before sending another command. You can use either *OPC? or *OPC to help determine when each calibration step is completed.

Using the *OPC? query

With the *OPC? (operation complete) query, the instrument will place an ASCII 1 in the output queue when it has completed each step. To determine when the OPC response is ready, do the following:

1. Repeatedly test the MAV (Message Available) bit (bit 4) in the status byte and wait until it is set. (You can request the status byte by using the *STB? query.)
2. When MAV is set, a message is available in the output queue, and you can read the output queue and test for an ASCII 1.
3. After reading the output queue, repeatedly test MAV again until it clears. At this point the calibration step is completed.

Using the *OPC command

The *OPC (operation complete) command can be used to detect the completion of each calibration step. In order to use *OPC to detect the end of each calibration step, do the following:

1. Enable operation complete by sending *ESE 1. This command sets the OPC (operation complete bit) in the standard event enable register, allowing operation complete status from the standard event status register to set the ESB (event summary bit) in the status byte when operation complete is detected.
2. Send the *OPC command immediately following each calibration command. For example:

   :CAL:PROT:SENS:VOLT 8;*OPC

   Note that you must include the semicolon (;) to separate the two commands, and that the *OPC command must appear on the same line as the calibration command.
3. After sending a calibration command, repeatedly test the ESB (Event Summary) bit (bit 5) in the status byte until it is set. (Use *STB? to request the status byte.)
4. Once operation complete has been detected, clear OPC status using one of two methods: (1) use the *ESR? query, then read the response to clear the standard event status register, or (2) send the *CLS command to clear the status registers. Note that sending *CLS will also clear the error queue and operation complete status.

Generating an SRQ on calibration complete

An IEEE-488 bus SRQ (service request) can be used to detect operation complete instead of repeatedly polling the Model 2500. To use this method, send both *ESE 1 and *SRE 32 to the instrument, then include the *OPC command at the end of each calibration command line, as covered above. Clear the SRQ by querying the ESR (using the *ESR? query) to clear OPC status, then request the status byte with the *STB? query.

Refer to your controller's documentation for information on detecting and servicing SRQs.

C
Calibration Program

Introduction

This appendix includes a calibration program written in Basic to help you in calibrating the Model 2500 Dual Photodiode Meter. Refer to Section 2 for more details on calibration procedures, equipment, and connections. Appendix B covers calibration commands in detail.

Computer hardware requirements

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

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

Software requirements

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

- Microsoft QBasic (supplied with MS-DOS 5.0 or later) or Quick Basic.
- MS-DOS version 5.0 or later or Windows 95/98.
- HP-style Universal Language Driver, CECHP.EXE (supplied with Keithley and CEC interface cards listed above).

Calibration equipment

The following calibration equipment is required:

- Keithley Model 263 Calibrator/Source.
- Keithley Model 2001 DMM.

See Section 2 for detailed equipment specifications.

General program instructions

1. With the power off, connect the Model 2500, calibrator, and the digital multimeter to the IEEE-488 interface of the computer. Be sure to use shielded IEEE-488 cables for bus connections.
2. Turn on the computer, the Model 2500, and the digital multimeter. Allow the Model 2500 and the multimeter to warm up for at least one hour before performing calibration.
3. Make sure the Model 2500 is set for a primary address of 25. (Use the front panel MENU/COMMUNICATIONS/GPIB selection to check or change the address.)
4. Set the calibrator primary address to 17 and digital multimeter primary address to 16.
5. Make sure that the computer bus driver software (CECHP.EXE) is properly initialized.
6. Enter the QBasic editor, and type in the program below.
7. Check thoroughly for errors, then save it using a convenient filename.
8. Run the program, and follow the prompts on the screen to perform calibration. For test connections, refer to the following figures in Section 2:
   - Channel 1 bias voltage calibration connections: Figure 2-1.
   - Channel 2 bias voltage calibration connections: Figure 2-2.
   - Channel 1 current measurement calibration connections: Figure 2-3.
   - Channel 2 current measurement calibration connections: Figure 2-4.

Program C-1 Model 2500 calibration program

```
' Model 2500 calibration program for use with Keithley 2001 DMM and
' Model 263 Calibrator/Source
' 2500 address = 25.  2001 address = 16. 263 address = 17
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 25 16 17"              ' Put 2500, 2001, 263 in remote.
PRINT #1, "OUTPUT 25;*RST"               ' Initialize 2500.
PRINT #1, "OUTPUT 25;*CLS"               ' Clear 2500 status.
PRINT #1, "OUTPUT 25;*ESE 1;*SRE 32"     ' Enable OPC and SRQ.
PRINT #1, "OUTPUT 16;:SYST:PRES"         ' Initialize 2001.
PRINT #1, "OUTPUT 16;:FORM:ELEM READ"    ' 2001 reading data only.
PRINT #1, "CLEAR 17"                     ' Reset 263
'
CLS
PRINT "Model 2500 Calibration Program"
GOSUB KeyCheck
PRINT #1, "OUTPUT 25;:CAL:PROT:CODE 'KI002500'"
' Voltage bias calibration.
FOR I = 1 TO 34
READ Cmd$
SELECT CASE I
        CASE 1
                PRINT "Connect shielded cap to channel 1 INPUT jack."
                GOSUB KeyCheck
        CASE 2
                PRINT "Connect DMM INPUT to Ch. 1 OUTPUT and INPUT LO"
                GOSUB KeyCheck
        CASE 18
                PRINT "Connect shielded cap to channel 2 INPUT jack."
                GOSUB KeyCheck
        CASE 19
                PRINT "Connect DMM INPUT to Ch. 2 OUTPUT and INPUT LO."
                GOSUB KeyCheck
        CASE 5, 7, 9, 12, 14, 16, 22, 24, 26, 29, 31, 33
                GOSUB ReadDMM
                Cmd$ = Cmd$ + Reading$
END SELECT
PRINT #1, "OUTPUT 25;"; Cmd$; ";*OPC"
GOSUB CalEnd
GOSUB ErrCheck
NEXT I
'Channel 1 current calibration.
Range = 2E-09: CalPlus = 1.9E-09: CalMinus = -1.9E-09
PRINT "Connect 263 Calibrator output to 2500 channel 1 INPUT jack."
GOSUB KeyCheck
PRINT #1, "OUTPUT 17;F1R0O1X"                  ' Set up 263.
FOR I = 1 TO 8                                 ' Loop for all ranges.
PRINT #1, "OUTPUT 25;:SENS1:CURR:RANG "; Range  ' Set 2500 range.
PRINT #1, "OUTPUT 17;"; CalPlus; "X"           ' + FS current cal.
```

```
PRINT #1, "OUTPUT 25;:CAL:PROT:SENS1 "; CalPlus; ";*OPC"
GOSUB CalEnd
PRINT #1, "OUTPUT 17;V0X"                       ' 0 current cal.
PRINT #1, "OUTPUT 25;:CAL:PROT:SENS1 0;*OPC"
GOSUB CalEnd
PRINT #1, "OUTPUT 17;V"; CalMinus; "X"          ' - FS current cal.
PRINT #1, "OUTPUT 25;:CAL:PROT:SENS1 "; CalMinus; ";*OPC"
GOSUB CalEnd
GOSUB ErrCheck
Range = Range * 10: CalPlus = CalPlus * 10: CalMinus = CalMinus * 10
NEXT I
PRINT #1, "OUTPUT 17;O0X"
' Channel 2 current calibration
Range = 2E-09: CalPlus = 1.9E-09: CalMinus = -1.9E-09
PRINT "Connect 263 Calibrator output to 2500 channel 2 INPUT jack."
GOSUB KeyCheck
PRINT #1, "OUTPUT 17;O1X"
FOR I = 1 TO 8                                  ' Loop for all ranges.
PRINT #1, "OUTPUT 25;:SENS2:CURR:RANG "; Range  ' Set 2500 range.
PRINT #1, "OUTPUT 17;V"; CalPlus; "X"           ' + FS current cal.
PRINT #1, "OUTPUT 25;:CAL:PROT:SENS2 "; CalPlus; ";*OPC"
GOSUB CalEnd
PRINT #1, "OUTPUT 17;V0X"                       ' 0 current cal.
PRINT #1, "OUTPUT 25;:CAL:PROT:SENS2 0;*OPC"
GOSUB CalEnd
PRINT #1, "OUTPUT 17;V"; CalMinus; "X"          ' - FS current cal.
PRINT #1, "OUTPUT 25;:CAL:PROT:SENS2 "; CalMinus; ";*OPC"
GOSUB CalEnd
GOSUB ErrCheck
Range = Range * 10: CalPlus = CalPlus * 10: CalMinus = CalMinus * 10
NEXT I
PRINT #1, "OUTPUT 17;O0X"
LINE INPUT "Enter calibration date (yyyy,mm,dd): "; D$
PRINT #1, "OUTPUT 25;:CAL:PROT:DATE "; D$
LINE INPUT "Enter calibration due date (yyyy,mm,dd): "; D$
PRINT #1, "OUTPUT 25;:CAL:PROT:NDUE "; D$
PRINT #1, "OUTPUT 25;:CAL:PROT:SAVE"     ' Save calibration constants.
GOSUB ErrCheck
PRINT #1, "OUTPUT 25;:CAL:PROT:LOCK"     ' Lock out calibration.
PRINT "Calibration completed."
PRINT #1, "LOCAL 25 16"
CLOSE
END
'
KeyCheck:                                ' Check for key press routine.
WHILE INKEY$ <> "": WEND                 ' Flush keyboard buffer.
PRINT : PRINT "Press any key to continue (ESC to abort program)."
DO: I$ = INKEY$: LOOP WHILE I$ = ""
IF I$ = CHR$(27) THEN GOTO EndProg       ' Abort if ESC is pressed.
RETURN
'
CalEnd:                                  ' Check for cal step completion.
```

```
DO: PRINT #1, "SRQ?"                        ' Request SRQ status.
        INPUT #2, S                         ' Input SRQ status byte.
LOOP UNTIL S                                ' Wait for operation complete.
PRINT #1, "OUTPUT 25;*ESR?"                 ' Clear OPC.
PRINT #1, "ENTER 25"
INPUT #2, S
PRINT #1, "SPOLL 25"                        ' Clear SRQ.
INPUT #2, S
RETURN
'
ErrCheck:                                   ' Error check routine.
PRINT #1, "OUTPUT 25;:SYST:ERR?"            ' Query error queue.
PRINT #1, "ENTER 25"
INPUT #2, E, Err$
IF E <> 0 THEN PRINT Err$: GOTO ErrCheck ' Display error.
RETURN
'
ReadDMM:                                    ' Get reading from DMM.
SLEEP 3
PRINT #1, "OUTPUT 16;:READ?"
PRINT #1, "ENTER 16"
INPUT #2, Reading$
RETURN
'
EndProg:                                    ' Close files, end program.
BEEP: PRINT "Calibration aborted."
PRINT #1, "OUTPUT 25;:CAL:PROT:LOCK"
PRINT #1, "OUTPUT 25;*RST"
PRINT #1, "LOCAL 25 16 17"
CLOSE
END
'
CmdList:                                   ' Voltage bias cal commands.
DATA ":CAL:PROT:SOUR1:OFFS"
DATA ":OUTP1 ON",":SOUR1:VOLT:RANG 10",":SOUR1:VOLT 10","CAL:PROT:SOUR1 "
DATA ":SOUR1:VOLT 0",":CAL:PROT:SOUR1 ",":SOUR1:VOLT -10",":CAL:PROT:SOUR1 "
DATA ":SOUR1:VOLT:RANG 100",":SOUR1:VOLT 100","CAL:PROT:SOUR1 "
DATA ":SOUR1:VOLT 0",":CAL:PROT:SOUR1 ",":SOUR1:VOLT -100"
DATA ":CAL:PROT:SOUR1 ",":OUTP1 OFF"
DATA ":CAL:PROT:SOUR2:OFFS"
DATA ":OUTP2 ON",":SOUR2:VOLT:RANG 10",":SOUR2:VOLT 10","CAL:PROT:SOUR2 "
DATA ":SOUR2:VOLT 0",":CAL:PROT:SOUR2 ",":SOUR2:VOLT -10",":CAL:PROT:SOUR2 "
DATA ":SOUR2:VOLT:RANG 100",":SOUR2:VOLT 100","CAL:PROT:SOUR2 "
DATA ":SOUR2:VOLT 0",":CAL:PROT:SOUR2 ",":SOUR2:VOLT -100"
DATA ":CAL:PROT:SOUR2 ",":OUTP2 OFF"
```

Index

V

Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

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

_____

_____

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

_____

❑ IEEE failure ❑ Obvious problem on power-up ❑ Batteries and fuses are OK

❑ Front panel operational ❑ All ranges or functions are bad ❑ Checked all cables

Display or output (check one)

❑ Drifts ❑ Unable to zero ❑ Unstable

❑ Overload ❑ Will not read applied input

❑ Calibration only ❑ Certificate of calibration required ❑ Data required

(attach any additional sheets as necessary)

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

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

_____

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

Relative humidity? _____Other?_____

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

_____

_____

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

KEITHLEY

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