Model DMM7510
7½ Digit Graphical Sampling Multimeter

Calibration and Adjustment Manual

DMM7510-905-01 Rev. B / February 2016

DMM7510-905-01B

A Greater Measure of Confidence

KEITHLEY

A Tektronix Company

Model DMM7510

Calibration and Adjustment Manual

Safety precautions

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

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

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

The types of product users are:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Do not exceed the maximum signal levels of the instruments and accessories, 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 the same type and rating for continued protection against fire hazard.

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

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

If a ⏚ screw is present, connect it to protective earth (safety ground) using the wire recommended in the user documentation.

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

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

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

The ⏛ symbol indicates a connection terminal to the equipment frame.

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

The **WARNING** heading in the user documentation explains 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 the user documentation 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. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley 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.

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

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., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Safety precaution revision as of March 2016.

Table of Contents

Introduction

In this section:

Welcome

Thank you for choosing a Keithley Instruments product. The Model DMM7510 is a 7½ digit graphical sampling multimeter that expands standard DMM functions with high-speed digitizing and large graphical color touchscreen display. This DMM offers a broad range of measurement capabilities, including 17 measurement functions. In addition to industry-leading DC accuracies, functions such as capacitance, 10 A current, and 18-bit current and voltage digitizing are included. Tying all these features together is a large 5-inch color touchscreen display that brings users an unprecedented combination of data visualization and interaction, enabling users to gain deeper insight into their measurements.

The Model DMM7510 provides superior measurement accuracy and the speed necessary for a broad range of applications, from system applications and production testing to benchtop applications. The Model DMM7510 meets application requirements for production engineers, research and development engineers, test engineers, and scientists.

Introduction to this manual

This manual provides instructions to help you calibrate and adjust your Keithley Instruments Model DMM7510. In this manual, the term "calibration" refers to the process of verifying that the accuracy of the instrument is within its one-year accuracy specifications. The term "adjustment" refers to the process of changing the calibration constants so that the accuracy of the instrument is within its one-year accuracy specifications.

This manual presents calibration information, adjustment information, and command descriptions for the calibration and adjustment commands.

NOTE

For additional command descriptions, refer to the *Model DMM7510 Reference Manual* (part number DMM7510-901-01). This manual is on the Product Information CD-ROM that came with your instrument. It is also available on the Downloads, Manuals, and Documentation web page (*http://www.tek.com/downloads*).

Extended warranty

Additional years of warranty coverage are available on many products. These valuable contracts protect you from unbudgeted service expenses and provide additional years of protection at a fraction of the price of a repair. Extended warranties are available on new and existing products. Contact your local Keithley Instruments office, sales partner, or distributor for details.

Contact information

If you have any questions after you review the information in this documentation, please contact your local Keithley Instruments office, sales partner, or distributor. You can also call the corporate headquarters of Keithley Instruments (toll-free inside the U.S. and Canada only) at 1-800-935-5595, or from outside the U.S. at +1-440-248-0400. For worldwide contact numbers, visit the Keithley Instruments website (*http://www.tek.com/keithley*).

Performance verification

Introduction

Use the procedures in this section to verify that Model DMM7510 accuracy is within the limits stated in the instrument's one-year accuracy specifications. Specifications and characteristics are subject to change without notice; refer to the Downloads, Manuals, and Documentation web page (*http://www.tek.com/downloads*) for the most recent specifications.

You can use these calibration verification procedures to:

* Make sure that the instrument was not damaged during shipment.
* Verify that the instrument meets factory specifications.
* Determine if adjustment is required.
* Verify that adjustment was done 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 appropriate safety precautions when working with hazardous voltages.

NOTE

If the instrument is still under warranty and its performance is outside specified limits, please contact your local Keithley Instruments office, sales partner, or distributor. You can also call the corporate headquarters of Keithley Instruments (toll-free inside the U.S. and Canada only) at 1-800-935-5595, or from outside the U.S. at +1-440-248-0400. For worldwide contact numbers, visit the Keithley Instruments website (*http://www.tek.com/keithley*).

Factory service

To return the instrument to Keithley Instruments for repair:

- Call the Repair Department at 1-800-833-9200 or send an email to RMAREQUEST@tektronix.com for a Return Material Authorization (RMA) number.
- Carefully pack the instrument in the original packing carton.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

Verification test requirements

Be sure that you perform these verification tests:

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

Environmental conditions

Conduct the calibration verification procedures in a test environment with:

- An ambient temperature of 18 °C to 28 °C (65 °F to 82 °F).
- A relative humidity of less than or equal to 80 percent, unless otherwise noted.
- No direct airflow on the input terminals.

Warmup period

Allow the Model DMM7510 to warm up for at least 90 minutes before conducting the calibration verification procedures.

If the instrument has been subjected to temperature extremes (more than 5 °C (9 °F) above T_{cal}), allow additional time for the internal temperature of the instrument to stabilize. Typically, allow an additional hour to stabilize an instrument that is 10 °C (18 °F) outside the specified temperature range.

Also, allow the test equipment to warm up for the amount of time recommended by the manufacturer.

Line power

The Model DMM7510 requires a line voltage of 100 V to 240 V and a line frequency of 50 Hz or 60 Hz. Calibration verification tests should be performed within this range.

NOTE

The instrument automatically senses the line frequency at power up.

Recommended test equipment

The following table summarizes the recommended calibration verification equipment. You can use alternate equipment if that equipment has specifications that meet or exceed those listed in the table below. Test equipment uncertainty adds to the uncertainty of each measurement. Generally, test equipment uncertainty should be at least four times more accurate than corresponding Model DMM7510 specifications.

Manufacturer	Model	Description	Used for	Uncertainty
Fluke	5720A or 5730A	High-Performance Multifunction Calibrator	DCV, ACV, ACI, and resistance	See Note.
Fluke	5725A	Amplifier	DCI and ACI	See Note.
Fluke	8508A	8.5-Digit Reference Multimeter	DCV and resistance	See Note.
Keithley Instruments	3390	Function/Arbitrary Waveform Generator	Frequency	See Note.
IET Labs, Inc.	1423-A	Precision Decade Capacitor	Capacitance, 1 nF to 1 µF	See Note.
IET Labs, Inc.	HACS-Z-A-2E-1uF	Series HACS-Z High Accuracy Decade Capacitance Box	Capacitance, 1 µF to 100 µF	See Note.
Keithley Instruments	8610 or 8620	4-Wire DMM Shorting Plug	DCV, digitize DCV, and resistance	See Note.
HYMEG Corporation	FA-65-1G and FA-65-10G	1 GΩ and 10 GΩ, 2 % tolerance, 25 PPM/ °C resistor	910 MΩ, parallel 1 GΩ and 10 GΩ	See Note.

NOTE

Refer to the manufacturer's specifications to calculate the uncertainty, which varies for each function and range test point.

NOTE

In this manual, the Model 8610 shorting plug is shown in the figures. However, you can use either the Model 8610 or Model 8620.

Autocalibration

Autocalibration removes measurement errors that are caused by the performance drift on the components used in this DMM as a result of temperature and time. Autocalibration improves short-term accuracy of the Model DMM7510. However, you must still perform regular full calibration adjustment with metrology equipment to maintain overall accuracy. To maintain accuracy, run autocalibration when the instrument temperature changes by more than ±5 °C or one week has elapsed since the last autocalibration. To check the temperature difference, you can view the temperature change on the Calibration menu. You can also use remote commands to retrieve the temperature difference.

The instrument regularly monitors the internal temperature for the voltage, current, 2-wire resistance, 4-wire resistance, diode, temperature, and DC voltage ratio function when autozero is enabled. Temperature checking begins after the warm-up time completes. If you are using digitize functions, periodically check the temperature drift by using the front-panel calibration screen or use remote commands to check the autocalibration temperature drift. If there is a more than ±5 °C difference between this temperature and the temperature when the last autocalibration was run, the instrument generates an event in the event log and a warning message.

The autocalibration constants are stored through a power cycle. You do not need to run autocalibration because power has been cycled.

You can run autocalibration with input cables connected. At the start of the autocalibration process, the front terminals are monitored. If more than 30 V DC or 1 V AC is detected on the front-panel inputs, autocalibration is not run and an event message is displayed.

Autocalibration also monitors the temperature at the start and end of autocalibration. If the start and end temperature differs by more than ±1 °C, the autocalibration values are not stored and a warning message is generated.

Running autocalibration

After the instrument has completed its warm up period, you can run autocalibration as needed using the front panel or over a remote interface. Autocalibration takes about six minutes to run. During autocalibration, you cannot use the instrument.

A status message is displayed on the front panel of the instrument while autocalibration is running. At completion, a status message is generated.

> ⚠ **CAUTION**
>
> To prevent instrument damage, verify that no test voltages are connected to the input terminals when performing autocalibration.
>
> Do not cycle power during the autocalibration routine. Doing so could affect the accuracy of the instrument.

To prepare for autocalibration:

1. Disable voltage sources on any test cables that are connected to the front-panel or rear-panel terminals.
2. Place the Model DMM7510 in a temperature-stable location.
3. Turn on instrument power and allow the instrument to warm up for at least 90 minutes. When the instrument has completed the warm-up period, a message is displayed and an information event is generated in the event log.

To run autocalibration from the front panel:

1.   Press the **MENU** key.
2.   Under System, select **Calibration**.
3.   Select **Start ACAL**. A prompt is displayed.

Select **Yes**. A progress bar is displayed while the calibration runs.

To run autocalibration using SCPI commands:

Send:

```
ACAL:RUN
```

To run autocalibration using TSP commands:

Send:

acal.run()

NOTE

Once autocalibration has started, you cannot stop it. After completion, however, you can use remote commands to revert to the previous autocalibration settings. If you are using SCPI commands, refer to :ACAL:REVert for detail. If you are using TSP commands, refer to acal.revert() (on page 4-6).

Scheduling autocalibration

You can set up your instrument to run autocalibration automatically. You can also set up the instrument to prompt you to run autocalibration at regular intervals. To determine the best schedule for your application, see the Model DMM7510 specifications for detail on the accuracy with and without autocalibration.

Autocalibration does not start until all actions that are active on the instrument are complete. When the scheduled time occurs, the autocalibration run command is placed in the command queue and will be executed after any previously sent commands or actions have executed. For example, if a trigger model is running when autocalibration is scheduled to run, autocalibration does not start until the trigger model stops.

If there is a command or action that is waiting a long time for an event, the autocalibration will not run until the event occurs, the action is aborted, or the instrument power is cycled.

If the scheduled time for autocalibration occurs before the warmup period completes, the instrument will not start autocalibration. The instrument waits until the warmup period is complete before starting a scheduled autocalibration. A message is displayed when warmup is complete and autocalibration is going to run.

If the instrument is powered off when an autocalibration was scheduled, autocalibration is run as soon as the warmup period is complete when the instrument is powered on.

You can run autocalibration manually even if a scheduled autocalibration is set.

When autocalibration is scheduled to run at a scheduled interval, but it runs at a time other than the scheduled interval, subsequent scheduled intervals are adjusted according to the actual autocalibration start time.

From the front panel:

1. Press the **MENU** key.
2. Under System, select **Calibration**.
3. Select **Scheduling Action**. To have the instrument:
    ▪ Prompt you to run autocalibration: Select **Notify**.
    ▪ Run autocalibration at a specific time: Select **Run**.
    ▪ To stop scheduling: Select **None**. If you select None, you do not need to make additional settings.
4. Select **Scheduling Interval**.
5. Select the interval.
6. Select **Scheduled Time** to select the time when the autocalibration will run or when you will be prompted to run it.

To review the next schedule time and date, see the information listed next to Next Run.

Using SCPI commands:

Refer to :ACAL:SCHedule.

Using TSP commands:

Refer to acal.schedule() (on page 4-7).

Reviewing calibration information

The Calibration screen displays information about the last autocalibration and factory calibrations that were run and the present status. For detail on this screen, refer to "System Calibration menu" in the *Model DMM7510 Reference Manual*.

For autocalibration, you can also access this information from the commands in the SCPI ACAL subsystem or the TSP `acal.*` commands.

Monitoring internal temperature

You can monitor the temperature difference between the actual internal temperature and the temperature when autocalibration ran through the front panel or by using remote commands. With remote commands, you can also check the present internal temperature and the internal temperature when autocalibration was last run. Temperature is returned in Celsius (°C).

The internal temperature is not updated on the Calibration screen until the warmup period is complete. The remote commands always return the present temperature.

From the front panel:

1. Press the **MENU** key.
2. Under System, select **Calibration**.
3. The Temperature Difference is displayed.

Using SCPI commands:

For the present internal temperature, send:

```
:SYSTem:TEMPerature:INTernal?
```

For the temperature difference, send:

```
:ACAL:LASTrun:TEMPerature:DIFFerence?
```

For the temperature when autocalibration was last run, send:

```
:ACAL:LASTrun:TEMPerature:INTernal?
```

Using TSP commands:

For the present internal temperature, send:

```
print(localnode.internaltemp)
```

For the temperature difference, send:

```
print(acal.lastrun.tempdiff)
```

For the temperature when autocalibration was last run, send:

```
print(acal.lastrun.internaltemp)
```

Calibration verification limits

The calibration verification limits stated in this section have been calculated using only the Model DMM7510 one-year accuracy specifications, within 30 days of autocalibration and T_{oper} ±5 °C from T_{acal}. They do not include test equipment uncertainty. If a particular measurement falls outside the allowable range, recalculate new limits based on both the Model DMM7510 specifications and corresponding test equipment specifications.

Specifications and characteristics are subject to change without notice; please refer to the Keithley Instruments website (*http://www.tek.com/keithley*) for the most recent specifications.

Example reading limit calculation

Assume you are testing the 10 VDC range using a 10 V input value. Using the Model DMM7510 one-year accuracy specification for 10 VDC of ± (14 ppm of reading + 1.2 ppm of range), the calculated limits are:

Reading limits = 10 V ± [(10 V × 14 ppm) + (10 V × 1.2 ppm)]

Reading limits = 10 V ± (0.00014 + 0.000012) V

Reading limits = 10 V ± 0.000152 V

Reading limits = 9.999848 V to 10.000152 V

Calculating resistance reading limits

Resistance reading limits must be recalculated based on the actual calibration resistance values supplied by the equipment manufacturer. Calculations are performed in the same manner as shown in the preceding example. Use the actual calibration resistance values instead of the nominal values in the example when performing your calculations.

For example, assume that you are testing the 10 kΩ range using an actual 10.03 kΩ calibration resistance value. Using Model DMM7510 one-year 10 kΩ range accuracy of $\pm$ (30 ppm of reading + 3 ppm of range), the calculated reading limits are:

Reading limits = 10.03 kΩ $\pm$ [(10.03 kΩ x 30 ppm) + (10 kΩ x 3 ppm)]

Reading limits = 10.03 kΩ $\pm$ [(0.3009) + (0.03)] Ω

Reading limits = 10.03 kΩ ± 0.3309 Ω

Reading limits = 10.029669 kΩ to 10.030331 kΩ

Performing the verification test procedures

The following topics provide a summary of calibration verification test procedures and items to consider before performing any calibration verification test.

Test summary

Front-panel tests:

- DC voltage verification (on page 2-9)
- AC voltage verification (on page 2-12)
- Digitize voltage verification (on page 2-16)
- Frequency verification (on page 2-19)
- Simulated thermocouple type J temperature verification (on page 2-20)
- Simulated RTD temperature verification (on page 2-22)
- Dry circuit resistance verification (on page 2-26)
- Resistance verification (on page 2-25)
- DC current verification (on page 2-34)
- Digitize current verification (on page 2-38)
- AC current verification (on page 2-41)
- Capacitance verification (on page 2-43)
- Verifying zero values using a 4-wire short (on page 2-45)

Rear-panel tests:

- DC current 10 A range verification (on page 2-47)
- Digitize current 10 A range verification (on page 2-50)
- AC current 10 A verification (on page 2-51)

If the Model DMM7510 is not within specifications and is not under warranty, see the adjustment procedures in <u>Adjustment</u> (on page 3-1) for information about adjusting the instrument.

Test considerations

When performing the calibration verification procedures:

- Be sure to restore factory front-panel defaults. From the front panel, select the **MENU** key, select **Info/Manage**, and select **System Reset**.
- Make sure that the test equipment is warmed up for the amount of time recommended by the manufacturer and is connected to the Model DMM7510 input/output terminals.
- Ensure that the correct Model DMM7510 terminals are selected with the TERMINALS FRONT/REAR button.
- Make sure the test equipment is set up for the proper function and range.
- Do not connect test equipment to the Model DMM7510 through a scanner, multiplexer, or other switching equipment.

NOTE
Ensure autocalibration has been performed with 30 days and that the temperature difference is less than ±5 °C. To check autocalibration, press the **MENU** key and select **Calibration**. If elapsed time is more than 30 days or the temperature difference is more than ±5 °C, run autocalibration before verifying the Model DMM7510.

⚠ WARNING
The front and rear terminals of the instrument are rated for connection to circuits rated Measurement Category II up to 300 V, as described in International Electrotechnical Commission (IEC) Standard IEC 60664. This range must not be exceeded. Do not connect the instrument terminals to CAT III or CAT IV circuits. Connection of the instrument terminals to circuits higher than CAT II can cause damage to the equipment and severe personal injury.

Front-panel calibration verification

The following topics describe verification procedures that are done with connections attached to the terminals on the Model DMM7510 front panel.

DC voltage verification

⚠ WARNING
The maximum input voltage between INPUT HI and INPUT LO is 1000 V_{PEAK}. Exceeding this value may create a shock hazard.
The maximum common-mode voltage (the voltage between INPUT LO and chassis ground) is 500 V_{PEAK}. Exceeding this value may cause a breakdown in insulation that can create a shock hazard.

Verify DC voltage accuracy for the 100 mV to 1000 V ranges

To verify 100 mV to 1000 V DC voltage accuracies, you will:

- Apply accurate DC voltages from the calibrator to the Model DMM7510 front-panel terminals.
- Verify that the displayed readings are within specified limits.

Use the values in the tables following the steps below to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

> # NOTE
> Use shielded low-thermal connections when testing the 100 mV and 1 V ranges to avoid errors caused by noise or thermal effects. Connect the shield to the output LO terminal of the calibrator.

To verify DC voltage accuracy:

1. Use a low-thermal cable to connect the Model DMM7510 HI and LO INPUT terminals to the calibrator HI and LO terminals as shown in the following figure.

Figure 1: DC voltage 100 mV to 1000 V ranges verification connections
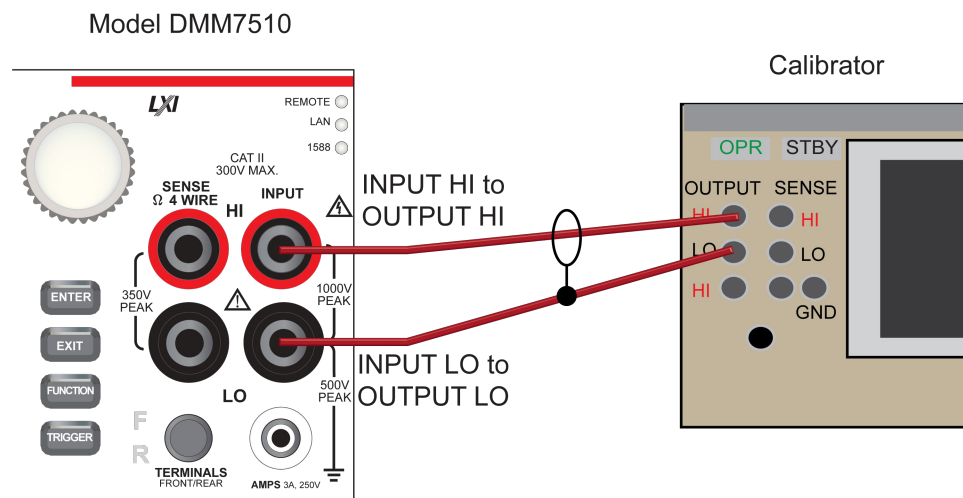
2. On the Model DMM7510, press the **FUNCTION** key and select **DC voltage**.
3. On the Home screen, select the button next to Range and select **100 mV**.
4. Press the **MENU** key.
5. Select **Settings**.
6. Set Input Impedance to **Auto**.
7. Set the calibrator output to **0 V**.
8. Set the calibrator to **OPERATE**.
9. Allow 5 minutes of settling time.

10. Press the **MENU** key.
11. Select **Calculations**.
12. Select **Rel Acquire**.
13. Source positive and negative full-scale and half-scale voltages and allow for proper settling, as listed in Verify the DC voltage 100 mV range (on page 2-11).
14. Select each range on the Model DMM7510, allow for proper settling, and verify the remaining ranges according to the following tables.

Verify the DC voltage 100 mV range

Description	Verification point	Lower limit	Upper limit
Perform relative offset	0.0	n/a	n/a
Full scale (+)	1.0000000E-01	9.9997300E-02	1.0000270E-01
Half scale (+)	5.0000000E-02	4.9998200E-02	5.0001800E-02
Half scale (−)	−5.0000000E-02	−5.0001800E-02	−4.9998200E-02
Full scale (−)	−1.0000000E+02	−1.0000270E-01	−9.9997300E-02

Verify the DC voltage 1 V range

Description	Verification point	Lower limit	Upper limit
Full scale (+)	1.0000000E+00	9.9998300E-01	1.0000170E+00
Half scale (+)	5.0000000E-01	4.9999050E-01	5.00009500E-01
Half scale (−)	−5.0000000E-01	−5.0000950E-01	−4.9999050E-01
Full scale (−)	−1.0000000E+00	−1.0000170E+00	−9.9998300E-01

Verify the DC voltage 10 V range

Description	Verification point	Lower limit	Upper limit
Full scale (+)	1.000000E+01	9.999848E+00	1.0000152E+01
Half scale (+)	5.000000E+00	4.9999180E+00	5.0000820E+00
Half scale (−)	−5.0000000E+00	−5.0000820E+00	−4.9999180E+00
Full scale (−)	−1.0000000E+01	−1.0000152E+01	−9.999848E+00

Verify the DC voltage 100 V range

> ⚠ **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 appropriate safety precautions when working with hazardous voltages.*

Description	Verification point	Lower limit	Upper limit
Full scale (+)	1.000000E+02	9.999730E+01	1.0000270E+02
Half scale (+)	5.000000E+01	4.999840E+01	5.000160E+01
Half scale (−)	−5.0000000E+01	−5.0001600E+01	−4.999840E+01
Full scale (−)	−1.0000002E+01	−1.0000270E+02	−9.999730E+01

Verify the DC voltage 1000 V range

Description	Verification point	Lower limit	Upper limit
Full scale (+)	1.0000000E+03	9.9997200E+02	1.0000280E+03
Half scale (+)	5.000000+02	4.9998350E+02	5.0001650E+02
Half scale (-)	−5.000000+02	−5.0001650E+02	−4.9998350E+02
Full scale (-)	−1.0000000E+03	−1.0000280E+03	−9.9997200E+02

AC voltage verification

To verify AC voltage accuracy, you will:

- For the 100 mV to 100 V ranges, apply accurate voltages from the calibrator to the Model DMM7510 front-panel terminals.
- For the 700 V range, connect the Fluke 5725A Amplifier to the calibrator. Apply accurate voltages from the calibrator terminals to the terminals on the front panel of the Model DMM7510.
- Verify that the displayed readings are within specified limits.

Use the values in the tables following the steps below to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

⚠ WARNING

The maximum input voltage between INPUT HI and INPUT LO is 1000 V$_{PEAK}$. Exceeding this value may create a shock hazard.

The maximum common-mode voltage (the voltage between INPUT LO and chassis ground) is 500 V$_{PEAK}$. Exceeding this value may cause a breakdown in insulation that can create a shock hazard.

Verify AC voltage accuracy for the 100 mV to 100 V ranges

NOTE

Use shielded, low-capacitance cabling. For the 100 mV to 100 V ranges, avoid loading that exceeds 1000 pF.

Excessive capacitance may result in additional load regulation uncertainties and could cause the calibrator output to open (go into standby).

To verify AC voltage accuracy:

1. Connect the Model DMM7510 HI and LO INPUT connectors to the calibrator as shown in the following figure.

Figure 2: Connections for AC voltage verification 100 mV to 100 V ranges
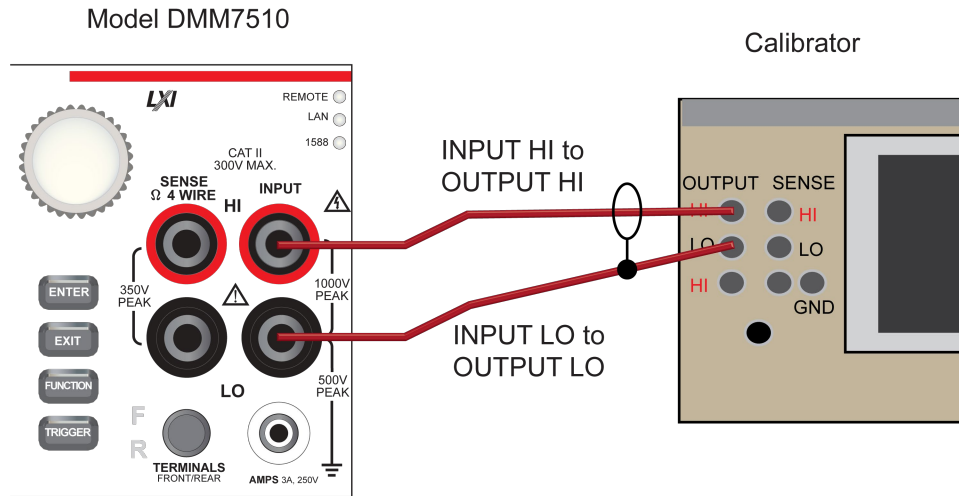
2. On the Model DMM7510, press the **FUNCTION** key and select **AC voltage**.
3. On the Home screen, select the button next to Range and select **100 mV**.
4. Press the **MENU** key.
5. Select **Settings**.
6. Ensure that detector bandwidth is set to **30 Hz**.

NOTE

AC voltage is specified for the detector bandwidth setting of 3 Hz. 3 Hz measures accurately for input signals from 3 Hz to 300 kHz, with reading rates ≈ 0.5 readings/s. To improve verification throughput to ≈ 3.3 readings/s, set detector bandwidth to 30 Hz for frequencies of 30 Hz to 300 kHz. To verify frequencies 1 kHz and higher, set the detector bandwidth to 300 Hz for faster ≈ 55 readings/s throughput.

7. Source AC voltages for each of the frequencies listed in the Verify the AC voltage 100 mV range (on page 2-13) table.
8. Repeat these steps for each range and frequency listed in the tables below. For each voltage setting, be sure that the reading is within low and high limits.

Verify the AC voltage 100 mV range

Input	Frequency	Lower limit	Upper limit
0.1	3.0E+01	9.991000E-02	1.000900E-01
0.1	1.0E+03	9.991000E-02	1.000900E-01
0.1	5.0E+04	9.981000E-02	1.001900E-01
0.1	1.0E+05	9.932000E-02	1.006800E-01

Verify the AC voltage 1 V range

Input	Frequency	Lower limit	Upper limit
1	3.0E+01	9.991000E-01	1.000900E+00
1	1.0E+03	9.991000E-01	1.000900E+00
1	5.0E+04	9.981000E-01	1.001900E+00
1	1.0E+05	9.932000E-01	1.006800E+00

Verify the AC voltage 10 V range

Input	Frequency	Lower limit	Upper limit
10	3.0E+01	9.991000E+00	1.000900E+01
10	1.0E+03	9.991000E+00	1.000900E+01
10	5.0E+04	9.981000E+00	1.001900E+01
10	1.0E+05	9.932000E+00	1.006800E+01

Verify the AC voltage 100 V range

Input	Frequency	Lower limit	Upper limit
100	3.0E+01	9.991000E+01	1.000900E+02
100	1.0E+03	9.991000E+01	1.000900E+02
100	5.0E+04	9.981000E+01	1.001900E+02
100	1.0E+05	9.932000E+01	1.006800E+02

Verify AC voltage accuracy for the 700 V range

NOTE
Use shielded low capacitance cabling. For the 700 V range, avoid cable capacitances of >150 pF.
Excessive capacitance may result in additional load regulation uncertainties and could cause the calibrator output to open (go into standby).

To verify AC voltage accuracy for the 700 V range:

1. Put the calibrator in Standby.
2. Connect the Model DMM7510 HI and LO INPUT connectors to the calibrator as shown in the following figure.
3. For 700 V at 50 kHz and 100 kHz outputs, connect the calibrator to the Fluke 5725A amplifier.

Figure 3: Connections for AC voltage accuracy verification 700 V range
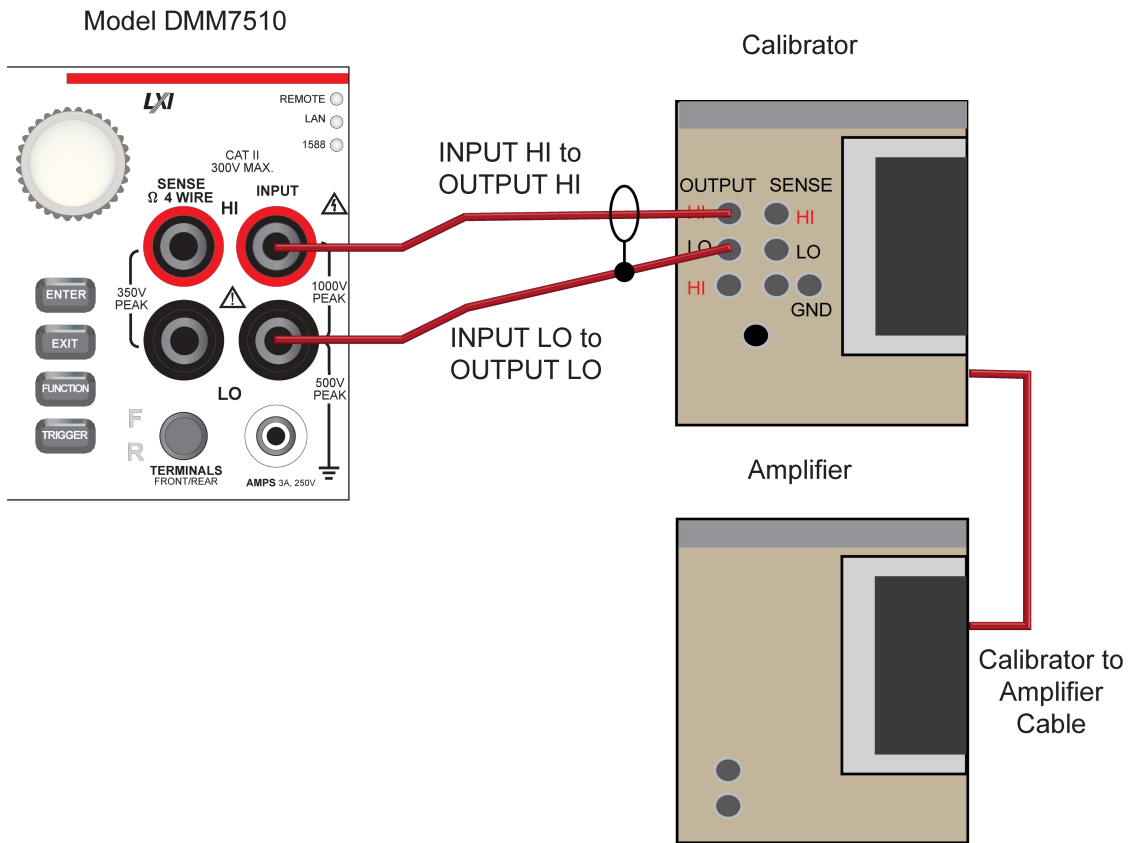
4. On the Model DMM7510, press the **FUNCTION** key and select **AC voltage**.

5. On the Home screen, select the button next to Range and select **700 V**.

6. Press the **MENU** key.

7. Select **Settings**.

8. Ensure that detector bandwidth is set to **30 Hz**.

NOTE

AC voltage is specified for the detector bandwidth setting of 3 Hz. 3 Hz measures accurately for input signals from 3 Hz to 300 kHz, with reading rates ≈ 0.5 readings/s. To improve verification throughput to ≈ 3.3 readings/s, set detector bandwidth to 30 Hz for frequencies of 30 Hz to 300 kHz. To verify frequencies 1 kHz and higher, set the detector bandwidth to 300 Hz for faster ≈ 55 readings/s throughput.

9. Set the calibrator to **OPERATE**.

10. Source AC voltages for each of the frequencies listed in the "Verify the AC voltage 700 V range" table, below. Be sure that the readings are within low and high limits.

Verify the AC voltage 700 V range

Input	Frequency	Lower limit	Upper limit
700	5.0E+01	6.993700E+02	7.006300E+02
700	1.0E+03	6.993700E+02	7.006300E+02
700	5.0E+04	6.986700E+02	7.013300E+02
700	1.0E+05	6.952400E+02	7.047600E+02

Digitize voltage verification

To verify digitize voltage accuracy, you will:

● Apply accurate voltages from the calibrator to the terminals on the front panel of the Model DMM7510.

● Verify that the displayed readings are within specified limits.

Use the values in the tables following the steps below to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

⚠ WARNING

The maximum input voltage between INPUT HI and INPUT LO is 1000 V$_{PEAK}$. Exceeding this value may create a shock hazard.

The maximum common-mode voltage (the voltage between INPUT LO and chassis ground) is 500 V$_{PEAK}$. Exceeding this value may cause a breakdown in insulation that can create a shock hazard.

Verify the digitize voltage 100 mV to 1000 V ranges

<table>
<tr><td align="center">NOTE</td></tr>
<tr><td>Use shielded low-thermal connections when testing the 100 mV and 1 V ranges to avoid errors caused by noise or thermal effects. Connect the shield to the output LO terminal of the calibrator.</td></tr>
</table>

To verify digitize voltage accuracy:

1. Connect the Model DMM7510 HI and LO INPUT connectors to the calibrator as shown in the following figure.

Figure 4: Connections for digitize voltage verification 100 mV to 1000 V ranges
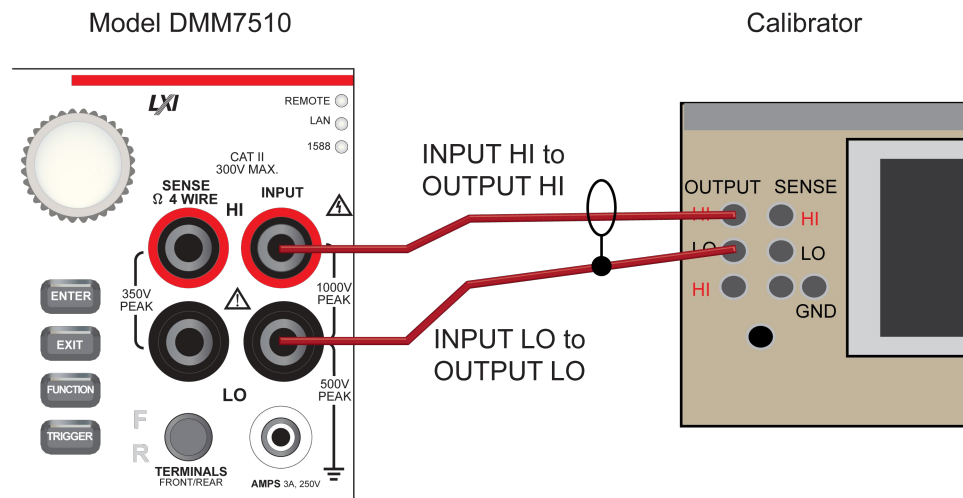
2. On the Model DMM7510, press the **FUNCTION** key, select the **Digitize Functions** tab, and select **Digitize Voltage**.
3. On the Home screen, select the button next to Range and select **100 mV**.
4. Press the **MENU** key.
5. Select **Settings**.
6. Set the Sample Rate to **1000**.
7. Set the Aperture to **Auto**.
8. Set the Count to **100**.
9. Set the calibrator output to 0.00000 mV DC and allow the reading to settle.
10. Press the **MENU** key.
11. Select **Calculations**.
12. Select **Rel Acquire**.
13. Source positive and negative full-scale and half-scale voltages, as listed in the following table. Verify the 1 V to 100 V range settings listed in the tables below. For each voltage setting, verify that the STATISTICS swipe screen reading for Average is within low and high limits.

<table>
<tr><td align="center">NOTE</td></tr>
<tr><td>The Fluke 5720A or 5730A calibrator 1000 V range 0.0 V setting is not verified.</td></tr>
</table>

Verify the digitize voltage 100 mV range

Description	Input	Lower limit	Upper limit
Perform relative offset	0.0	n/a	n/a
Full scale (+)	0.1	9.99680E-02	1.00032E-01
Half scale (+)	0.05	4.99790E-02	5.00210E-02
Half scale (−)	-0.05	−5.00210E-02	−4.99790E-02
Full scale (−)	-0.1	−1.00032E-01	−9.99680E-02

Verify the digitize voltage 1 V range

Description	Input	Lower limit	Upper limit
Verify zero	0	−7.50E-05	7.50E-05
Full scale (+)	1	9.99805E-01	1.00020E+00
Half scale (+)	0.5	4.99865E-01	5.00135E-01
Half scale (−)	−0.5	−5.00135E-01	−4.99865E-01
Full scale (−)	−1	−1.00020E+00	−9.99805E-01

Verify the digitize voltage 10 V range

Description	Input	Lower limit	Upper limit
Verify zero	0	−7.50E-04	7.50E-04
Full scale (+)	10	9.99805E+00	1.00020E+01
Half scale (+)	5	4.99865E+00	5.00135E+00
Half scale (−)	−5	−5.00135E+00	−4.99865E+00
Full scale (−)	−10	−1.00020E+01	−9.99805E+00

Verify the digitize voltage 100 V range

Description	Input	Lower limit	Upper limit
Verify zero	0	−7.50E-03	7.50E-03
Full scale (+)	100	9.99805E+01	1.00020E+02
Half scale (+)	50	4.99865E+01	5.00135E+01
Half scale (−)	−50	−5.00135E+01	−4.99865E+01
Full scale (−)	−100	−1.00020E+02	−9.99805E+01

Verify the digitize voltage 1000 V range

Description	Input	Lower limit	Upper limit
Full scale (+)	1000	9.99805E+02	1.00020E+03
Half scale (+)	500	4.99865E+02	5.00135E+02
Half scale (−)	−500	−5.00135E+02	−4.99865E+02
Full scale (−)	−1000	−1.00020E+03	−9.99805E+02

Frequency verification

To verify frequency accuracy, you will:

- Apply accurate frequencies from the function generator to the terminals on the front panel of the Model DMM7510.
- Verify that the displayed readings are within specified limits.

Use the values in the table following the steps below to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

To verify the Model DMM7510 frequency function:

1. Connect the Keithley Instruments Model 3390 function generator to the Model DMM7510 INPUT HI and LO terminals as shown in the following figure.

Figure 5: Connections for frequency verification and adjustment
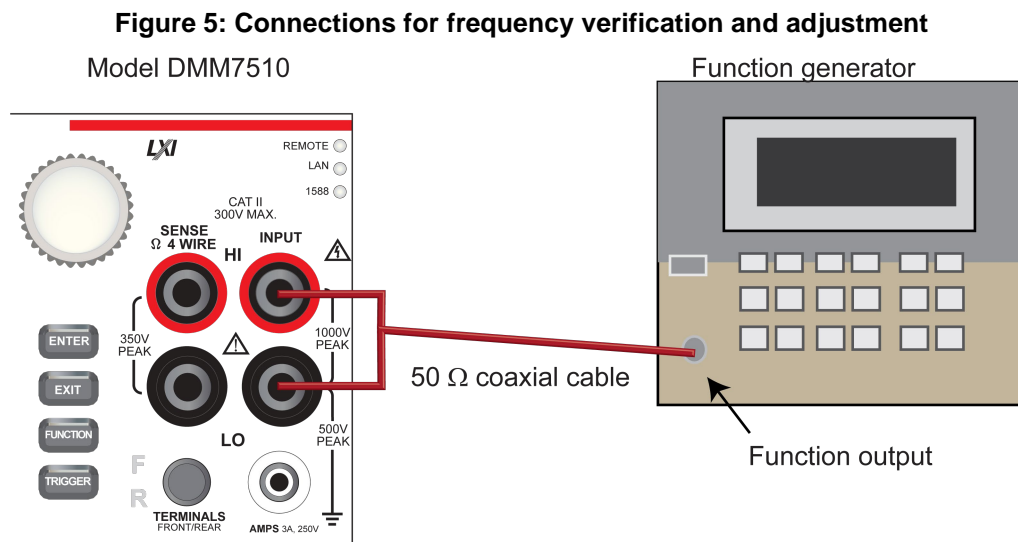
2. Set the function generator output impedance to **High**, amplitude of **5 V**$_{RMS}$, waveform to **square wave**.
3. Enable the output.
4. On the Model DMM7510, press the **FUNCTION** key, select the **Measure Functions** tab, and select **Frequency**.
5. Select the **MENU** key.
6. Select **Settings**.
7. Set the Aperture to **250 ms**.
8. Set the Threshold Range to **10 V**.
9. Set the Threshold Level to **0 V**.
10. Press the **HOME** key.
11. Source the voltage and frequency values as listed in Verify the frequency (on page 2-20). For each setting, be sure that the reading is within low and high limits.

Verify the frequency

Use the following values to verify the performance of the Model DMM7510. Actual values depend on published specifications (see Example reading limit calculation (on page 2-7)).

Description	Frequency (Hz)	Lower limit (Hz)	Upper limit (Hz)
10 Hz at 5 V	1.00E+01	9.999197E+00	1.000080E+01
1 kHz at 5 V	1.00E+03	9.999197E+02	1.000080E+03
10 kHz at 5 V	1.00E+04	9.999197E+03	1.000080E+04
100 kHz at 5 V	1.00E+05	9.999197E+04	1.000080E+05
250 kHz at 5 V	2.50E+05	2.499799E+05	2.500201E+05
500 kHz at 5 V	5.00E+05	4.999598E+05	5.000402E+05

Simulated thermocouple type J temperature verification

To verify thermocouple accuracy, you will:

- Apply accurate voltages from the calibrator to the terminals on the front panel of the Model DMM7510.
- Verify that the displayed readings are within specified limits.

Thermocouple accuracy is verified by using a DC voltage calibrator to output values from standard thermocouple tables available from the National Institute of Standards and Technology (NIST) or other sources.

In the table following the steps below, three representative values are listed from a Type J thermocouple table for temperatures –190 °C, 0 °C, and 750 °C, with their respective thermocouple voltages listed in the "Uncompensated calibrator source value" column. The calibrator source values are based on NIST Monograph 175, reference data 60, version 2.0.

Verify thermocouple accuracy

NOTE

Because the cable connecting the calibrator to the Model DMM7510 can have non-trivial thermal offset voltages, you must first correct for these to verify the Model DMM7510 specifications.

To verify the simulated thermocouple Type J temperature:

1. Connect the Model DMM7510 HI and LO INPUT terminals to the calibrator HI and LO terminals as shown in the following figure.

Figure 6: Connections for thermocouple verification
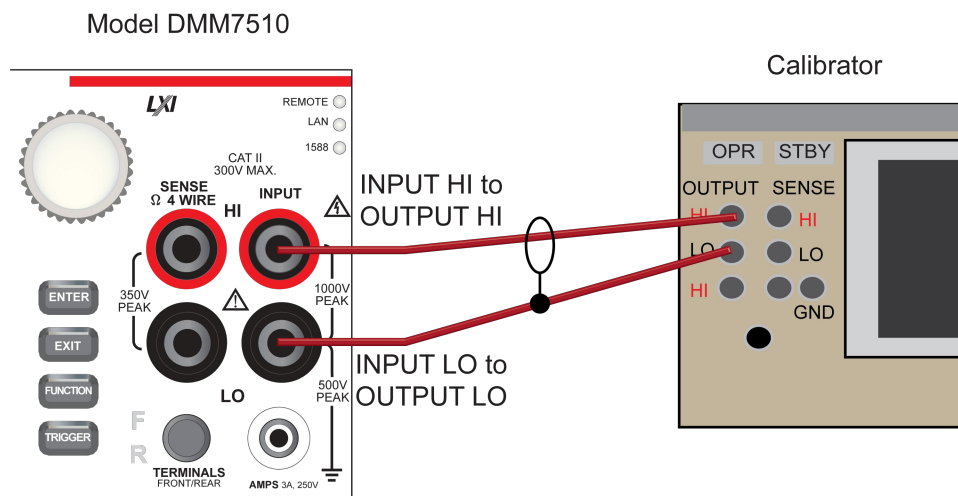
2. On the Model DMM7510, press the **FUNCTION** key and select **DC voltage**.

3. Press the **MENU** key.

4. Select **Settings**.

5. Set the range to **100 mV**.

6. Set input impedence to **Auto**.

7. Set autozero to **On**.

8. Select the button next to Integration Rate. The Integration Rate dialog box opens.

9. Next to Unit, select **NPLC**.

10. Next to NPLC, select **1 PLC.**

11. Select **OK** and press the **HOME** key to return to the Home Screen.

12. Set the calibrator to output **0 V** and enable the output.

13. Allow five minutes for settling of the thermal voltage.

14. Record the measured offset voltage to 1 µV precision. If necessary, use the Model DMM7510 filter settings to reduce the noise of this measurement (for filter settings, go to **MENU > Measure Calculations**).

15. Press the Model DMM7510 **FUNCTION** key and select **Temperature**.

16. Press the **MENU** key.

17. Select **Settings**.

18. On the Measure Settings screen, set the following values:

    *   Units: **°C**
    *   Transducer: **TC**
    *   Thermocouple: **J**
    *   Temperature (simulated reference temperature): **0 °C**
    *   Integration Rate: **1 PLC**
    *   Auto Zero: **On**

19. Set the calibrator to the simulated thermocouple voltage you want (from the table above), first correcting for the offset voltage measured in step 14. For example, if the measured offset voltage was −2 μV, set the calibrator to −7.659 mV − (−0.002 mV), which equals −7.657 mV, to simulate −190 °C.

20. Verify that the Model DMM7510 reading is within lower and upper limits.

21. Repeat steps 17 and 18 for each value in the following table.

Use the following values to verify the performance of the Model DMM7510. Actual values depend on published specifications (see Example reading limit calculation (on page 2-7)).

Simulated temperature	Uncompensated calibrator source value (V)	Lower limit	Upper limit
−190 °C	−7.659 mV	−190.2 °C	−189.8 °C
0 °C	0.000 mV	−0.2 °C	0.2 °C
750 °C	42.281 mV	749.8 °C	750.2 °C

Simulated RTD temperature verification

Use the following information to verify the performance of the Model DMM7510. Actual calibrator source values will vary. RTD verification is based on the calibrator sourcing resistance and the Model DMM7510 conversion of the resistance measurement to calculated temperature based on the Callendar-Van Dusen equation.

To verify RTD temperature accuracy, you will:

- Apply accurate resistance from the calibrator to the terminals on the front panel of the Model DMM7510.
- Verify that the displayed readings are within specified limits.

RTD equations

The temperature versus resistance readings listed in the RTD reference tables are calculated using the Callendar-Van Dusen equation. There are two equations that are based on different temperature ranges. There is an equation for the −200 °C to 0 °C range and one for the 0 °C to 850 °C range.

Equation for −200 °C to 0° C temperature range

$R_{RTD} = R_0 [1 + AT + BT^2 + CT^3(T-100)]$

where:

- R_{RTD} is the calculated resistance of the RTD
- R_0 is the known RTD resistance at 0 °C
- T is the temperature in °C
- A = alpha [1 + (delta/100)]
- B = -1 (alpha)(delta)(1E-4)
- C = −1 (alpha)(beta)(1E-8)

The alpha, beta, and delta values are listed in the following table.

Equation for 0 °C to 850 °C temperature range

$R_{RTD} = R_0 (1 + AT + BT^2)$

where:

- R_{RTD} is the calculated resistance of the RTD
- R_0 is the known RTD resistance at 0 °C
- T is the temperature in °C
- A = alpha [1 + (delta/100)]
- B = −1 (alpha)(delta)(1E-4)

The alpha and delta values are listed in the following table.

RTD parameters for equations

The RTD parameters for the Callendar-Van Dusen equations are listed in the following table.

Model DMM7510 resistance to temperature device (RTD)

Type	Standard	Alpha	Beta	Delta	R_0 at 0 °C (Ω)
PT100	ITS-90	0.00385055	0.10863	1.49990	100.0000
D100		0.003920	0.10630	1.49710	
F100		0.003900	0.11000	1.49589	
PT385	IPTS-68	0.003850	0.11100	1.50700	
PT3916		0.003916	0.11600	1.50594	

Verify the simulated RTD temperature

Use the values in the tables following the steps below to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

To verify RTD accuracy:

1. For 4-wire accuracy, connect the Model DMM7510 INPUT and SENSE terminals to the calibrator as shown in the following figure.

Figure 7: Connections for 4-wire RTD accuracy verification
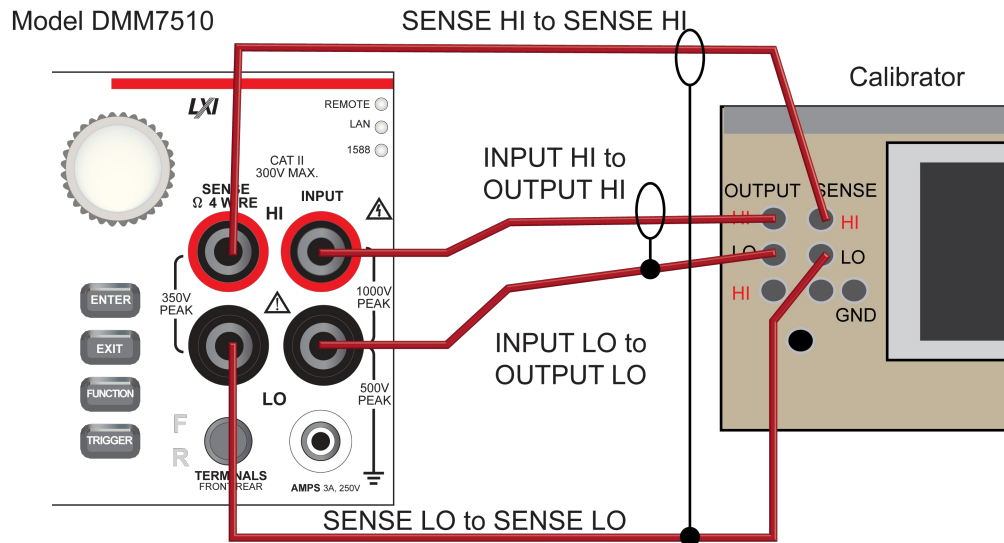
2. For 3-wire accuracy, connect the Model DMM7510 INPUT and SENSE terminals to the calibrator as shown in the following figure.

> ### NOTE
>
> The SENSE HI wire is not required for 3-wire RTD measurements. For 3-wire RTD, accuracy is for < 0.1 Ω lead resistance mismatch for input HI and LO. Add 0.25 °C per 0.1 Ω of HI-LO lead resistance mismatch.

Figure 8: Connections for 3-wire RTD accuracy verification
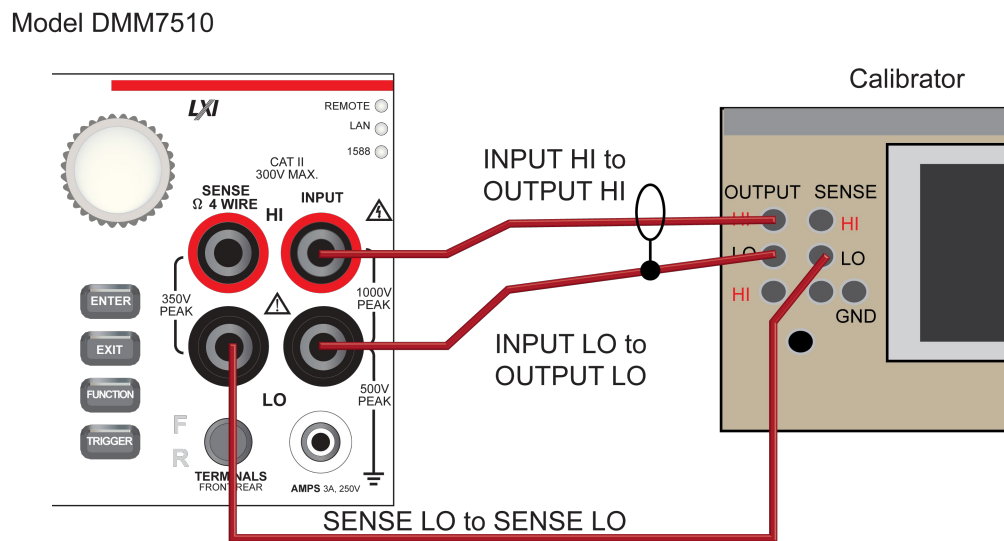
3. On the Model DMM7510, press the **FUNCTION** key and select **Temperature**.
4. Press the **MENU** key.
5. Select **Settings**.
6. Select **Transducer**.
7. Set the Type to either **4-wire RTD** or **3-Wire RTD**.
8. Set the RTD Type to **PT100**.
9. Press the **HOME** key.
10. On the calibrator, select **19 Ω** source resistance.
11. Select the **OPER** and **EX SNS** keys.
12. Record Model DMM7510 accuracies.
13. Refer to the table for PT100 accuracies.

NOTE

Fluke 5720 and 5730 resistance source values vary and may require new resistance-to-temperature target accuracy values.

14. Repeat for 100 Ω and 190 Ω source values.

Example	PT100	
	Ro	1.000000E+02
	alpha	3.850550E-03
	beta	1.086300E-01
	delta	1.499900E+00
	A	3.908304E-03
	B	-5.775440E-07
	C	-4.182852E-12

Nominal calibrator value (Ω)	Actual calibrator value (Ω)	Temperature (°C)	4-wire RTD ±0.06 °C accuracy (±Ω from actual calibrator value)	3-wire RTD ±0.75 °C accuracy (±Ω from actual calibrator value)
19	18.999520	-198.8900	0.0259	0.3241
100	99.99707	-0.0075	0.0235	0.2932
190	189.99234	238.6775	0.0218	0.2725

Resistance verification

Use the following information to verify the performance of the Model DMM7510 resistance functions.

Dry circuit resistance verification

To verify the dry circuit resistance function, you will:

- Use shielded, Teflon-insulated or equivalent cables in a 4-wire configuration.
- Characterize the calibrator 1 Ω and 10 Ω, nominal values, with the external reference DMM readings.
- For the 1 Ω and 10 Ω ranges, verify accuracy from the reference DMM readings.
- For the 100 Ω to 10 kΩ ranges, verify accuracy from actual calibrator source values.
- Verify that the displayed readings are within specified limits.

Characterize the calibrator for 1 Ω and 10 Ω

To characterize the calibrator:

1. Connect the calibrator and the reference DMM as shown in the figure below.
2. On the calibrator, enable the **OPR** key and the **EX SNS** key.
3. Ensure that the **OPERATE** display and **EX SNS** key are illuminated.
4. Source **0 Ω**.
5. On the reference DMM, enable **4-wire resistance** and **2 Ω range**.
6. Select **Ω PLUS**, then **TruΩ**, Resl to **RESL '7'**, and Fast **OFF**.
7. Verify **0 Ω**.
8. Perform range **ZERO** as required.
9. On the calibrator, source **1 Ω**.
10. On the reference DMM, record **1 Ω** reading.
11. Use the reading as the target for the Model DMM7510 1 Ω verification.
12. Repeat these steps for 10 Ω characterization.

Figure 9: Characterize the calibrator

Reference DMM
DC voltage

Calibrator
4-wire resistance

1 Ω and 10 Ω
target values

OUTPUT   SENSE

SENSE
HI

HI   LO

LO   LO

AMP

OPR
STBY   EX SNS

HI   GND
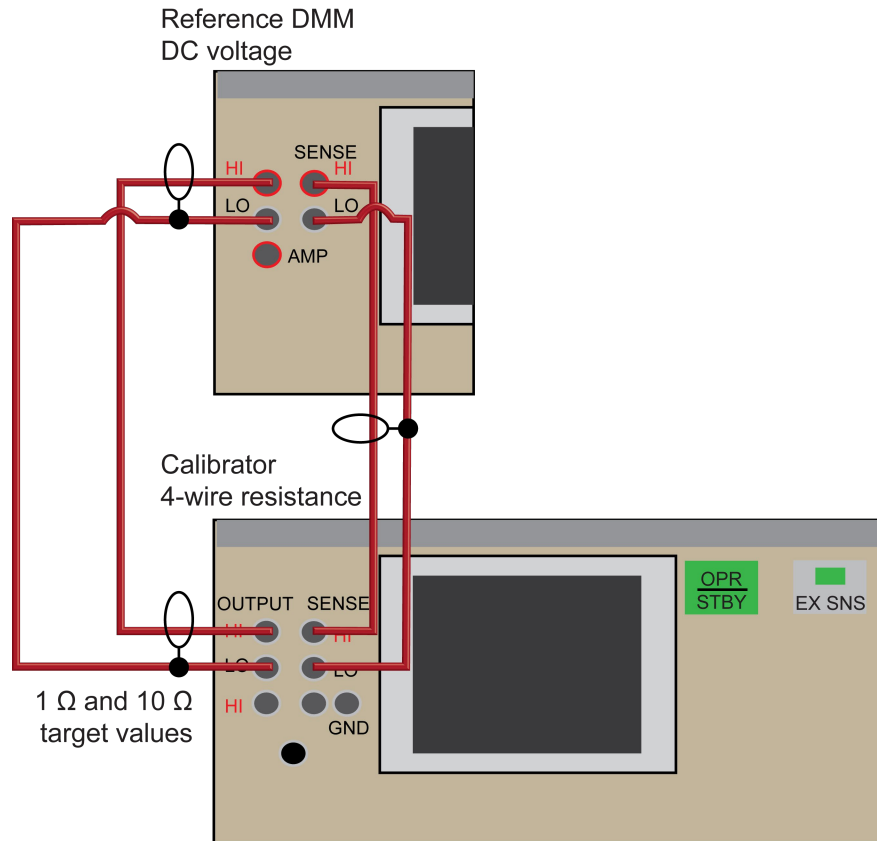
Verify dry circuit accuracy

Use the values in the tables following the steps below to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

To verify dry circuit resistance accuracy:

1. Connect the Model DMM7510 INPUT and SENSE terminals to the calibrator as shown in the following figure.

Figure 10: Connections for dry circuit accuracy verification
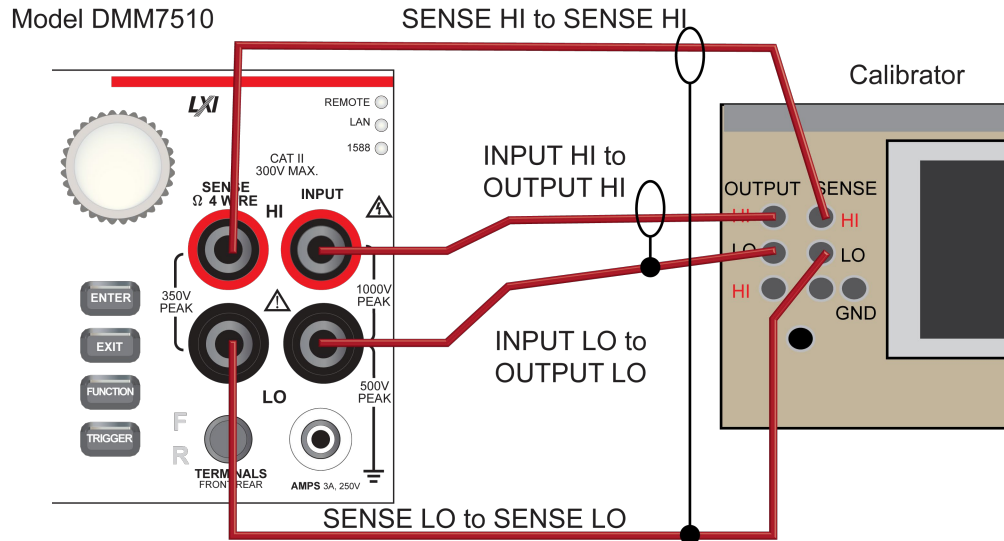
2. Set the calibrator for 4-wire resistance with external sense on.

3. On the Model DMM7510, press the **FUNCTION** key and select **4W Res**.

4. On the Home screen, select the button next to Range and select **1 Ω**.

5. Press the **MENU** key.

6. Select **Settings**.

7. Set Dry Circuit **On**. Verify that Offset Compensation is on (selecting Dry Circuit should automatically enable Offset Compensation).

8. Source the nominal full-scale resistance values for the 1 Ω to 2 kΩ ranges as shown in the following tables.

9. For the 10 kΩ range, verify with 1.9 kΩ. Overrange is 2.4 kΩ for the 10 kΩ range.

10. Select each range on the Model DMM7510, allow for proper settling, and verify the remaining ranges according to the following tables.

Verify dry circuit resistance values

The values and limits in the following tables are for example only. You must calculate test limits based on the actual resistance values output by your calibrator or resistance source (see Calculating resistance reading limits (on page 2-8)).

Range	Nominal calibrator value (Ω)	Typical reference DMM reading (Ω)	Lower limit (Ω)	Upper limit (Ω)
1	0		–8.00E-05	8.00E-05
	1.000000	1.0001568E+00	1.000027E+00	1.000287E+00
10	0		–8.00E-04	8.00E-04
	10.00000	9.9994500E+00	9.998150E+00	1.000075E+01

Range	Nominal calibrator value (Ω)	Actual calibrator value (Ω)	Lower limit (Ω)	Upper limit (Ω)
100	0		–8.00E-03	8.00E-03
	100.0000	9.9996340E01	9.997934E+01	1.000133E+02
1000	0		–8.00E-02	8.00E-02
	1000.000	9.9998410E+02	9.997241E+02	1.000244E+03
1.0E+04	0		–8.00E-01	8.00E-01
	1900.000	1.8999910E+03	1.898583E+03	1.901399E+03

4-wire resistance verification

To verify the 4-wire resistance function, you will:

- Use shielded, Teflon-insulated or equivalent cables in a 4-wire configuration.

- Characterize the calibrator 1 Ω, 10 Ω, and 909 MΩ nominal values with an external reference digital multimeter (DMM); verify accuracy from the reference DMM readings.

- For the 100 Ω to 100 MΩ ranges, verify accuracy from actual calibrator source values.

- Verify that the displayed readings are within specified limits.

Characterize the calibrator and 909 MΩ resistor

If not already complete, perform the procedure for characterizing the calibrator 1 Ω and 10 Ω source values. Refer to Characterize the calibrator for 1 Ω and 10 Ω (on page 2-26).

To characterize the 909 MΩ resistor:

1. Make connections between the resistor and the reference DMM as shown in the figure below.

Figure 11: Connections for 909 MΩ resistor characterization
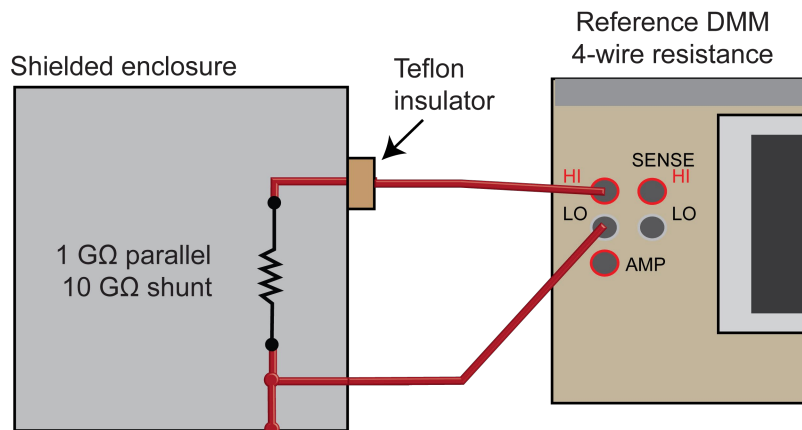
2. On the reference DMM, enable **2-wire resistance**.
3. Enable the **2 GΩ** range.
4. Select **Res1**.
5. Set to **RESL '7'**.
6. Verify **909 MΩ**.
7. On the reference DMM, record the 909 MΩ reading. Use this reading as the target for Model DMM7510 1 GΩ verification.

Verify 4-wire resistance accuracy

To verify 4-wire resistance accuracy:

1. Connect the Model DMM7510 INPUT and SENSE terminals to the calibrator as shown in the following figure.

Figure 12: Connections for 4-wire resistance accuracy verification
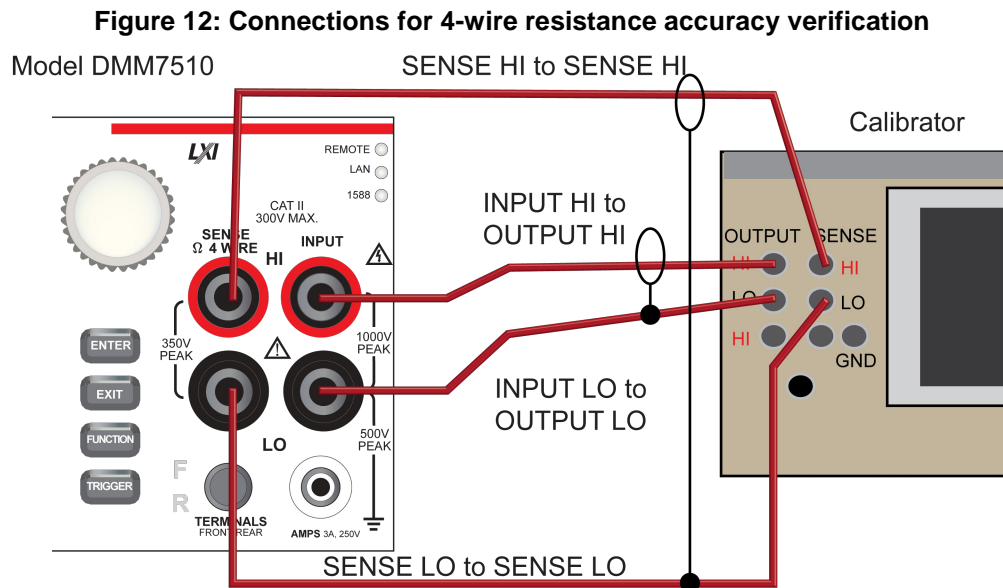
2. Set the calibrator for 4-wire resistance with external sense on.
3. On the Model DMM7510, press the **FUNCTION** key and select **4W Res**.
4. Press the **MENU** key.
5. Select **Settings**.
6. Set Offset Compensation **On**.
7. Verify that Open Lead Detector is **Off**.

8. On the Home screen, select the button next to Range and select **1 Ω**.

9. Source the nominal zero and full-scale resistance values for the 1 Ω to 10 kΩ ranges. Source the nominal zero value for the 100 kΩ range. Refer to the tables in .

10. For the 100 kΩ range, only verify 0 Ω with Offset Compensation set to **On**.

11. Set Offset Compensation to **Off**.

12. Verify full-scale 100 kΩ on the 100 kΩ range and 0 and full-scale for the 1 MΩ and 10 MΩ ranges.

13. Verify that the readings are within calculated limits.

> ## NOTE
>
> When Offset Compensation is set to On, ranges are limited to 1 Ω to 100 kΩ. When Offset Compensation is set to Off, all ranges (1 Ω to 1 GΩ) are available from all interfaces.

You can use either the front-panel controls or remote interface commands to set measurement parameters for verification. For calibration, you must use remote interface commands. The example below is an example of remote interface commands that will generate event messages.

To do the same steps over the remote interface, send the commands:

```
dmm.measure.func=dmm.FUNC_4W_RESISTANCE
dmm.measure.offsetcompensation.enable=dmm.ON
dmm.measure.range=1e6
```

The following warning message is displayed:

```
1131, Parameter, measure range, expected value from 1 to 100000
```

Set `dmm.measure.offsetcompensation.enable=dmm.OFF`, and then set `dmm.measure.range=1e6` to run without warnings.

Verify that the readings are within calculated limits.

The values and limits in the following tables are for example only. You must calculate test limits based on the actual resistance values output by your calibrator or resistance source (see Calculating resistance reading limits (on page 2-8)).

Range (Ω)	Nominal calibrator values (Ω)	Typical reference DMM reading (Ω)	Lower limit (Ω)	Upper limit (Ω)
1	0		−5.00E-05	5.00E-05
	1.00E+00	1.0001568E+00	1.000077E+00	1.000237E+00
10	0.00E+00		−5.00E-05	5.00E-05
	1.00E+01	9.9994500E+00	9.9991000E+00	9.9998000E+00

Range (Ω)	Nominal calibrator values (Ω)	Actual calibrator value (Ω)	Lower limit (Ω)	Upper limit (Ω)
100	0.00E+00		−4.00E-04	4.00E-04
	1.00E+02	9.9996340E+01	9.9993240E+01	9.9999440E+01
1000	0.00E+00		−3.00E-03	3.00E-03
	1.00E+03	9.9998410E+02	9.9995710E+02	1.0000111E+03
1.0E+04	0.00E+00		1.0E+04	0.00E+00
	1.00E+04	9.9999050E+03		1.00E+04
1.0E+05	0.00E+00		−3.00E-01	3.00E-01

4-wire resistance verification with offset compensation off

The values and limits in the following tables are for example only. You must calculate test limits based on the actual resistance values output by your calibrator or resistance source (see Calculating resistance reading limits (on page 2-8)).

NOTE
For 10 MΩ verification, the Sense HI cable is optional. Measurement is with Input HI and LO and Sense LO only.

Range (Ω)	Nominal calibrator values (Ω)	Actual calibrator value (Ω)	Lower limit (Ω)	Upper limit (Ω)
1.0E+05	1.00E+05	1.0000060E+05	9.9997300E+04	1.0000390E+05
1.0E+06	0.00E+00		−4.00E+00	4.00E+00
	1.00E+06	9.9995720E+05	9.9992320E+05	1.0000340E+06
1.0E+07	0.00E+00		−1.00E+02	1.00E+02
	1.00E+07	9.9989960E+06	9.9968962E+06	1.0001096E+07

Verify 2-wire resistance accuracy

To verify the 2-wire resistance function 100 MΩ and 1 GΩ ranges, you will:

- Use shielded, Teflon-insulated or equivalent cables in a 2-wire configuration.
- Apply accurate resistance from the calibrator to the terminals on the front panel of the Model DMM7510.
- Verify that the displayed readings are within specified limits.

Verify resistance 100 MΩ range

To verify the 100 MΩ range:

1. Connect the Model DMM7510 INPUT to the calibrator as shown in the following figure.

Figure 13: Connections for 100 MΩ verification
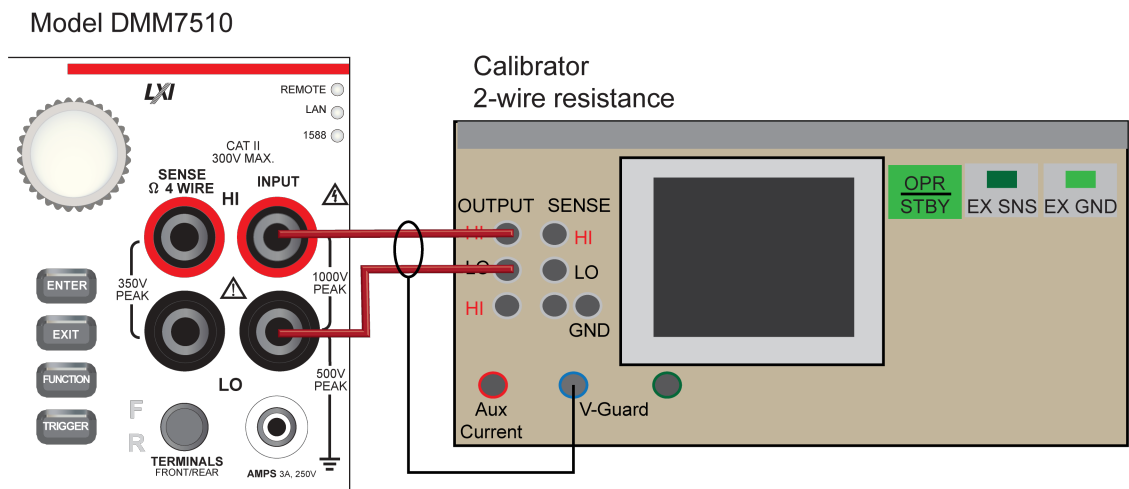
2.   Set the calibrator for 2-wire resistance with external sense off.

3.   On the Model DMM7510, press the **FUNCTION** key and select **2W Res**.

4.   On the Home screen, select the button next to Range and select **100 MΩ**.

5.   Source the nominal full-scale resistance values for the 100 MΩ range as shown in the following table.

The values and limits in the following tables are for example only. You must calculate test limits based on the actual resistance values output by your calibrator or resistance source (see Calculating resistance reading limits (on page 2-8)).

Range	Nominal calibrator values (Ω)	Actual calibrator (Ω)	Lower limit (Ω)	Upper limit (Ω)
1.0E+08	0.00E+00		−3.00E+03	3.00E+03
	1.00E+08	1.0000380E+08	9.980079E+07	1.002068E+08

Verify resistance 909 MΩ on the 1 GΩ range

To verify resistance on the 1 GΩ range:

1.   Connect the Model DMM7510 INPUT to the discrete shielded 909 MΩ reference resistor.

Figure 14: Connections for 1 GΩ range resistance verification
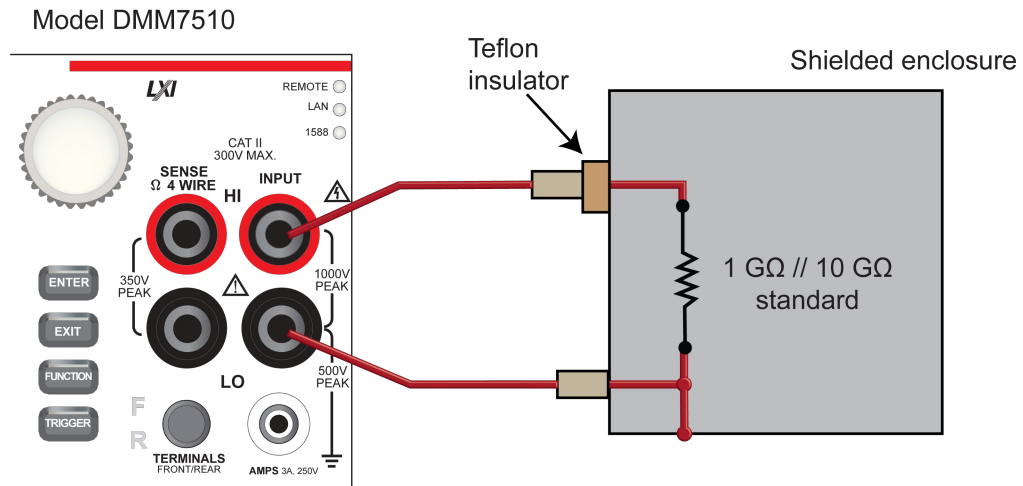
2.   On the Model DMM7510, press the **FUNCTION** key and select **2W Res**.

3.   On the Home screen, select the button next to Range and select **1GΩ.**

4.   Verify the 1 GΩ range as shown in the following table.

The values and limits in the following tables are for example only. You must calculate test limits based on the actual resistance values output by your calibrator or resistance source (see Calculating resistance reading limits (on page 2-8)).

Range	Nominal calibrator value (Ω)	Typical reference DMM reading (Ω)	Lower limit (Ω)	Upper limit (Ω)
1.0E+09	9.09E+08	9.081948E+08	8.999210E+08	9.164686E+08

DC current verification

The Model DMM7510 DC current ranges can be verified using several methods, depending on the level of measurement uncertainty required. This manual describes the verification procedure using a Fluke 8508A reference digital multimeter (DMM) in series with the Model DMM7510 to determine the nominal test current value for the 10 µA to 100 mA ranges. For the 1 A to 10 A ranges, this manual describes using direct output from a Fluke Model 5720A or 5725A calibrator.

NOTE

These configurations are adequate for most purposes, but may not provide sufficient test uncertainty ratio (TUR) for some users. You must evaluate the measurement uncertainties and ensure that they are adequate for your use.

DC current 10 µA to 100 mA range verification

When verifying DC current on the 10 µA to 100 mA ranges, systematic calibrator and cable offsets must be compensated and test limits calculated based on reference digital multimeter (DMM) readings.

In the following section, offset measurements may exceed Model DMM7510 zero-current measurement specifications due to systematic source offset current from the test setup.

NOTE

To verify the Model DMM7510 specifications with zero input current, disconnect all cables and calibrators from the Model DMM7510 input. This is a separate setup from that used in the procedure below for mid-scale and full-scale readings.

To prepare the Model DMM7510 for DC current accuracy verification:

1. Set up the Model DMM7510 for DC current and the range being tested. Make sure relative offset is disabled.
2. Connect the calibrator, Model DMM7510, and reference DMM as shown in the following figure.

Figure 15: DC current verification 10 µA to 100 mA range
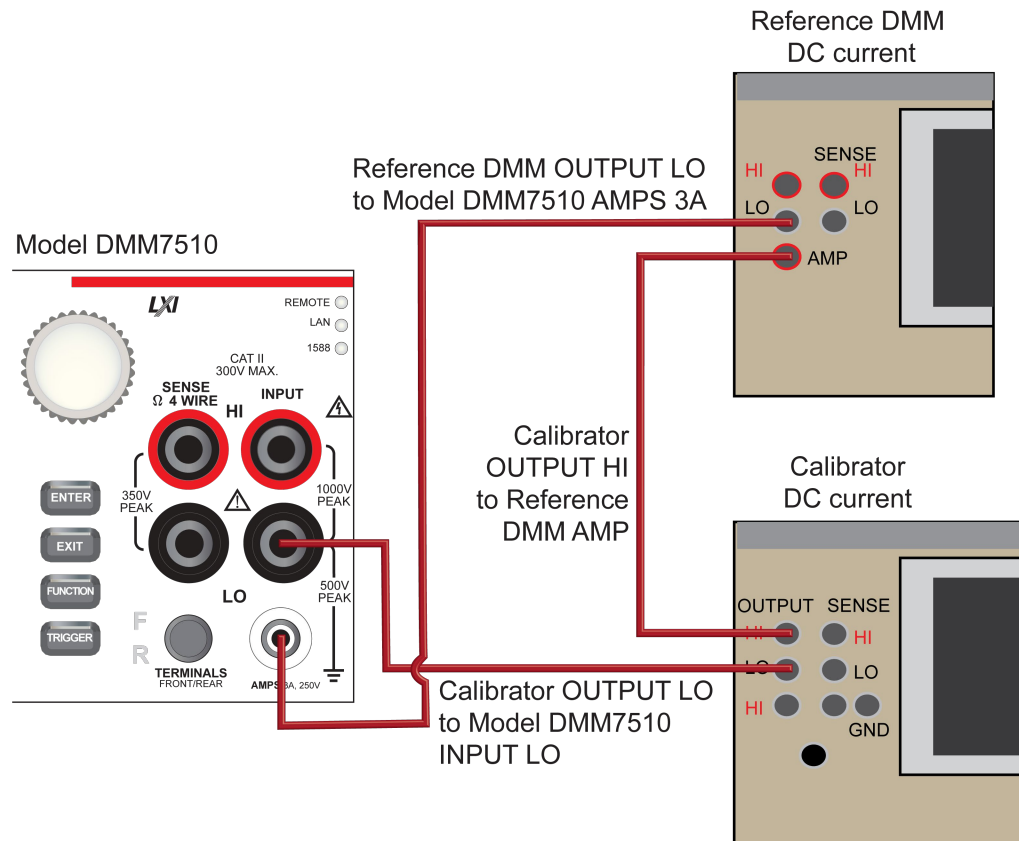
To verify Model DMM7510 accuracy for each range:

1. Set the calibrator to source zero current.

2. Set the reference DMM to **DC Current** and select the appropriate range to be verified. Use the Model 8508A 200 µA range to verify the Model DMM7510 10 µA and 100 µA ranges. Use the Model 8508A 2 mA, 20 mA, and 200 mA ranges to verify the Model DMM7510 1 mA, 10 mA, and 100 mA ranges, respectively.

3. On the calibrator, select the **OPR/STBY** key. Ensure that the front panel displays OPERATE.

4. On the Model DMM7510, press the **MENU** key.

5. Select **Calculations**. The Calculation Settings screen is displayed.

6. Select the button next to Rel and select **On** to enable the relative offset function.

7. Set the Rel Value to **0** to zero system offset values.

8. On the reference DMM, zero the range for system offset.

9. Set the calibrator to source the current for the range you are verifying (listed in the 1 mA verification table in Test limit calculation for 10 µA to 100 mA ranges (on page 2-36)).

10. Note the offset-compensated reference DMM reading, and calculate limits based on Model DMM7510 specifications (use the reference DMM reading as the expected value and verify the Model DMM7510 accuracy from the calculated reference DMM current).

11. Repeat steps 1 through 10 for all ranges (10 µA through 100 mA).

Test limit calculation for 10 µA to 100 mA ranges

The following tables list nominal test current for 10 µA to 100 mA ranges. Test limits must be calculated relative to actual current, as determined by the reference digital multimeter (DMM) measurement. For example, using a specification of 60 ppm of reading + 9 ppm of range on the 10 mA range, the reference DMM measures 5.00012 mA on the nominal 5 mA test.

Specification tolerance = 5.00012 (mA) $\times$ 60 ppm + 10 (mA) $\times$ 9 ppm = 0.000390072 mA

Lower test limit = 5.00012 − 0.000390072 = 4.999729928 mA

Upper test limit = 5.00012 + 0.000390072 = 5.000510072 mA

Although the specification tolerance calculated above from the actual test current differs slightly from the values listed in the table (based on nominal value), this difference is generally much smaller than the measurement uncertainty and can be ignored. As a result, the test limits can be calculated from the table specification tolerance as:

Lower test limit = 5.00012 − 0.00039 = 4.99973 mA

Upper test limit = 5.00012 + 0.00039 = 5.00051 mA

Range	Nominal input (µA)	Specification tolerance (µA) (based on nominal)
10 µA	0	REL
	10	0.00105
	5	0.00068
	−5	0.00068
	−10	0.00105

Range	Nominal input (µA)	Specification tolerance (µA) (based on nominal)
100 µA	0	REL
	100	0.0069
	50	0.0039
	−50	0.0039
	−100	0.0069

Range	Nominal input (mA)	Specification tolerance (mA) (based on nominal)
1 mA	0	REL
	1	0.000069
	0.5	0.000039
	−0.5	0.000039
	−1	0.000069

Range	Nominal input (mA)	Specification tolerance (mA) (based on nominal)
10 mA	0	REL
	10	0.00069
	5	0.00039
	−5	0.00039
	−10	0.00069

Range	Nominal input (mA)	Specification tolerance (mA) (based on nominal)
100 mA	0	REL
	100	0.0180
	50	0.0105
	−50	0.0105
	−100	0.0180

DC current 100 mA to 3 A range verification

To verify DC current accuracy on the 100 mA to 3 A ranges, you will:

• Apply accurate current from the DC current calibrator directly to the Model DMM7510 front-panel terminals.

• Verify that the displayed readings are within specified limits.

To verify DC current accuracy:

1. Set up the Model DMM7510 for DC current and the range being tested. Make sure relative offset is disabled.

2. Connect the Model DMM7510 and calibrator as shown in the following figure.

Figure 16: Connections for 100 mA to 3 A range verification
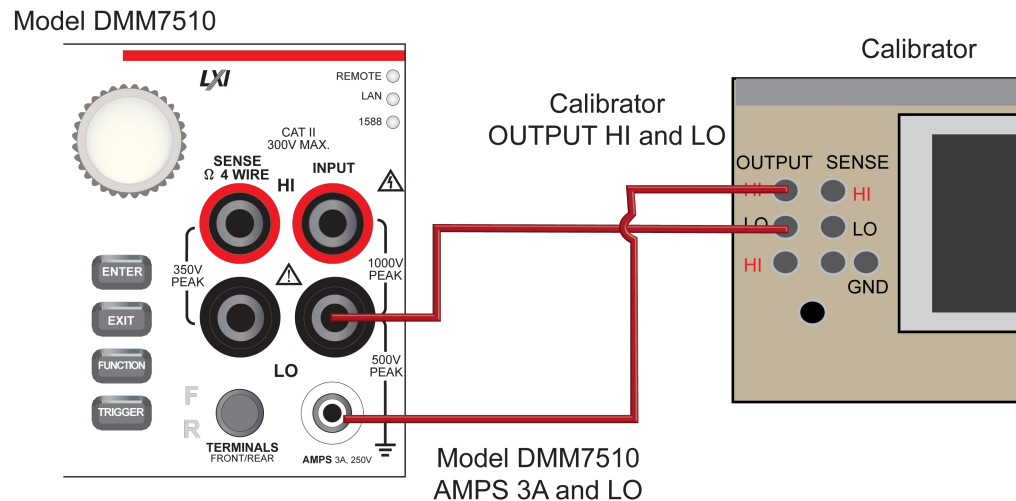
Zero verify the Model DMM7510:

1. On the calibrator, select the **OPR/STBY** key. Ensure that the front panel displays STANDBY.

2. Set the ranges to 100 mA.

3. Verify the Model DMM7510 zero reading for each range.

Apply a relative offset:

1. On the calibrator, select the **OPR/STBY** key. Ensure that the front panel displays OPERATE.

2. Set the calibrator to source zero current and apply the relative offset to the Model DMM7510.

3. Source DC current from the following table. For each setting, be sure that the reading is within stated limits.

4. Repeat these steps for the 1 A and 3 A ranges.

Verify DC current 100 mA range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	STANDBY	REL	n/a
Full scale (+)	0.1	9.9982000E-02	1.0001800E-01
Half scale (+)	0.05	4.9989500E-02	5.0010500E-02
Half scale (−)	−0.05	−5.0010500E-02	−4.9989500E-02
Full scale (−)	−0.1	−1.0001800E-01	−9.9982000E-02

Verify DC current 1 A range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	STANDBY	REL	n/a
Full scale (+)	0	9.9955000E-01	1.0004500E+00
Half scale (+)	1	4.9975000E-01	5.0025000E-01
Half scale (−)	0.5	−5.0025000E-01	−4.9975000E-01
Full scale (−)	−0.5	−1.0004500E+00	−9.9955000E-01

Verify DC current 3 A range

Description	Calibrator setpoint (A)*	Lower limit	Upper limit
UUT zero	STANDBY	REL	n/a
⅔ scale (+)	2	1.9990800E+00	2.0009200E+00
Half scale (+)	1.5	1.4992800E+00	1.5007200E+00
Half scale (−)	−1.5	−1.5007200E+00	−1.4992800E+00
⅔ scale (−)	−2	−2.0009200E+00	−1.9990800E+00

* The 3 A range full-scale test points are limited to 2 A in this table because of the accuracy
  limitations of Fluke Models 57xxA and 5725A series calibrators at currents above 2.2 A.

Digitize current verification

The following topics describe how to verify digitized DC current on the Model DMM7510.

Digitize DC current verification 10 µA to 3 A ranges

To verify digitize DC current accuracy:

1. Connect the Model DMM7510 and calibrator as shown in the following figure.

Figure 17: Connections for digitize DC current 10 µA to 3 A range verification
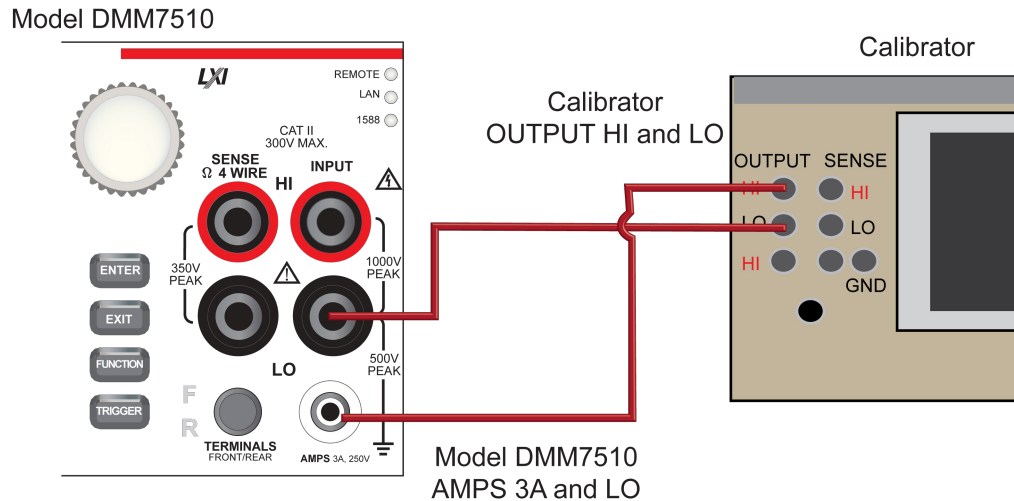
2. Press the **FUNCTION** key.
3. Select the **Digitize Functions** tab and select **Digitize Current**.
4. Press the **HOME** key.
5. Set the Range to **10 µA**.
6. Press the **MENU** key.
7. Select **Settings**.
8. Set the Sample Rate to **1000**.
9. Set the Aperture to **Auto** or **1 ms**.
10. Set the Count to **100**.
11. Apply a relative offset:
    a. Set the calibration current output to **NORMAL**.
    b. Set the calibrator output to **0 A**.
    c. On the calibrator, select the **OPR/STBY** key. Ensure that the front panel displays OPERATE.
    d. On the Model DMM7510, press the **MENU** key.
    e. Select **Calculations**.
    f. Select **Rel Acquire**.
12. Source positive and negative full-scale and half-scale currents, as listed in the following tables.
13. Repeat these steps for the 100 µA to 3 A range settings listed in the following tables.

Verify digitize current 10 µA range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	0	REL	n/a
Full scale (+)	0.000010	9.99765E-06	1.00024E-05
Half scale (+)	0.000005	4.99845E-06	5.00155E-06
Half scale (−)	−0.000005	−5.00155E-06	−4.99845E-06
Full scale (−)	−0.000010	−1.00024E-05	−9.99765E-06

Verify digitize current 1 mA range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	0	REL	n/a
Full scale (+)	0.00010	9.99765E-05	1.00024E-04
Half scale (+)	0.00005	4.99845E-05	5.00155E-05
Half scale (−)	−0.00005	−5.00155E-05	−4.99845E-05
Full scale (−)	−0.00010	−1.00024E-04	−9.99765E-05

Verify digitize current 1 mA range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	0	REL	n/a
Full scale (+)	0.001	9.99765E-04	1.00024E-03
Half scale (+)	0.0005	4.99845E-04	5.00155E-04
Half scale (−)	−0.0005	−5.00155E-04	−4.99845E-04
Full scale (−)	−0.001	−1.00024E-03	−9.99765E-04

Verify digitize current 10 mA range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	0	REL	n/a
Full scale (+)	0.01	9.99765E-03	1.00024E-02
Half scale (+)	0.005	4.99845E-03	5.00155E-03
Half scale (−)	−0.005	−5.00155E-03	−4.99845E-03
Full scale (−)	−0.01	−1.00024E-02	−9.99765E-03

Verify digitize current 100 mA range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	0	REL	n/a
Full scale (+)	0.1	9.99450E-02	1.00055E-01
Half scale (+)	0.05	4.99675E-02	5.00325E-02
Half scale (−)	−0.05	−5.00325E-02	−4.99675E-02
Full scale (−)	−0.1	−1.00055E-01	−9.99450E-02

Verify digitize current 1 A range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UUT zero	0	REL	n/a
Full scale (+)	1	9.99390E-01	1.00061E+00
Half scale (+)	0.5	4.99640E-01	5.00360E-01
Half scale (−)	−0.5	−5.00360E-01	−4.99640E-01
Full scale (−)	−1	−1.00061E+00	−9.99390E-01

Verify digitize current 3 A range

Description	Calibrator setpoint (A)*	Lower limit	Upper limit
UUT zero	0	REL	n/a
⅔ scale (+)	2	1.99775E+00	2.00225E+00
Half scale (+)	1.5	1.49820E+00	1.50180E+00
Half scale (−)	−1.5	−1.50180E+00	−1.49820E+00
⅔ scale (−)	−2	−2.00225E+00	−1.99775E+00

* The 3 A range full-scale test points are limited to 2 A in this table because of the accuracy
limitations of Fluke Models 57xxA and 5725A series calibrators at currents above 2.2 A.

AC current verification

The following topics describe how to verify AC current.

Verify AC current on the 1 mA to 3 A ranges

To verify AC current accuracy, you will:

- Apply accurate voltages from the Fluke 5720A or 5730A multifunction calibrator to the Model DMM7510 front-panel terminals.
- Verify that the displayed readings fall within specified limits.

Use the values in the following tables to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

To verify AC current accuracy:

1. On the Model DMM7510, press the **FUNCTION** key and select **AC Current**.
2. Press the **HOME** key.
3. Set the range you are verifying.
4. Press the **MENU** key.
5. Select **Settings**.
6. Ensure that Detector Bandwidth is set to **30 Hz**.

NOTE

AC current is specified for the detector bandwidth setting of 3 Hz. 3 Hz measures accurately for input signals from 3 Hz to 10 kHz, with reading rates of ≈ 0.5 readings/s. To improve verification throughput to ≈ 3.3 readings/s, set detector bandwidth to 30 Hz for frequencies of 30 Hz to 10 kHz. To verify frequencies 1 kHz and higher, set the detector bandwidth to 300 Hz for faster ≈ 55 readings/s throughput.

7. Connect the Model DMM7510 to the calibrator as shown in the following figure.

Figure 18: Connections for AC current verification
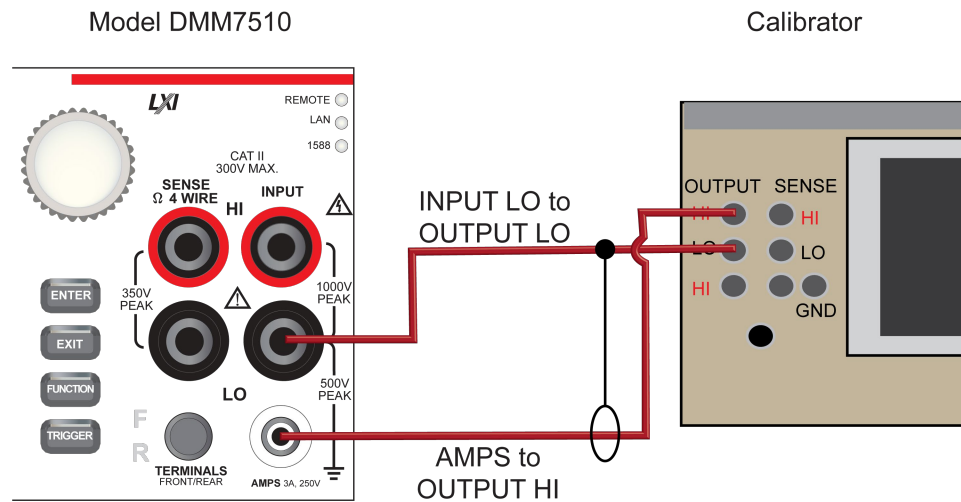
Model DMM7510   Calibrator

8. Source AC current for each of the frequencies listed in the following tables.
9. For each setting, be sure that the reading is within low and high limits.

Verify AC current 1 mA range

Description	Verification point	Lower limit	Upper limit
1 mA at 40 Hz	0.001	9.989000E-04	1.001100E-03
1 mA at 1 kHz	0.001	9.989000E-04	1.001100E-03
1 mA at 5 kHz	0.001	9.988000E-04	1.001200E-03

Verify AC current 10 mA range

Description	Verification point	Lower limit	Upper limit
1 mA at 40 Hz	0.010	9.989000E-03	1.001100E-02
1 mA at 1 kHz	0.010	9.989000E-03	1.001100E-02
1 mA at 5 kHz	0.010	9.988000E-03	1.001200E-02

Verify AC current 100 mA range

Description	Verification point	Lower limit	Upper limit
1 mA at 40 Hz	0.1	9.989000E-02	1.001100E-01
1 mA at 1 kHz	0.1	9.989000E-02	1.001100E-01
1 mA at 5 kHz	0.1	9.988000E-02	1.001200E-01

Verify AC current 1 A range

Description	Verification point	Lower limit	Upper limit
1 mA at 40 Hz	1.000	9.976000E-01	1.002400E+00
1 mA at 1 kHz	1.000	9.976000E-01	1.002400E+00
1 mA at 5 kHz	1.000	9.908000E-01	1.009200E+00

Verify AC current 3 A range

Description	Verification point	Lower limit	Upper limit
2 A at 40 Hz	2.000	1.994500E+00	2.005500E+00
2 A at 1 kHz	2.000	1.994500E+00	2.005500E+00
2 A at 5 kHz	2.000	1.980900E+00	2.019100E+00

Capacitance verification

To compensate for capacitance offset of the cable and 1 µF thru 100 µF decade box:

1. Connect the Model DMM7510, shielded banana cable, banana to dual BNC cable, and 1 µF through 100 µF decade capacitor box as shown in the following diagram.

Figure 19: Connect Model DMM7510 to decade capacitor box
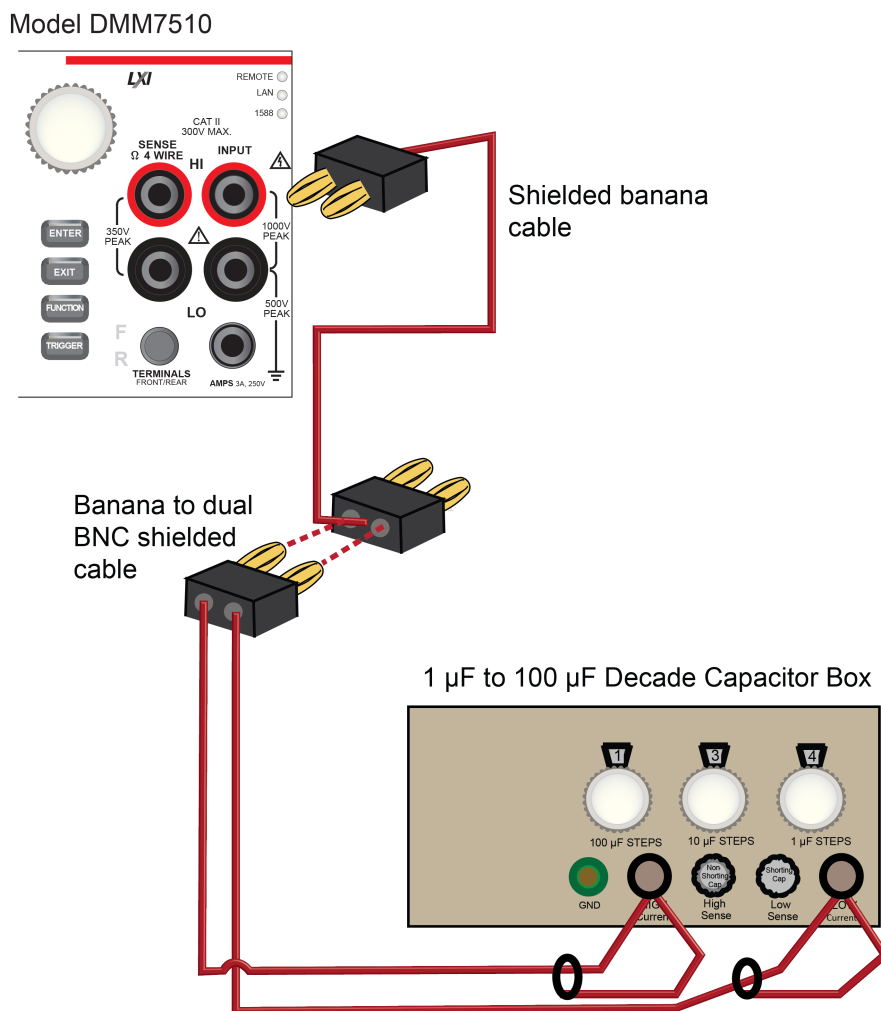
2. Set the decade capacitor box to **0 F**.

3. On the Model DMM7510, press the **FUNCTION** key, select the **Measure Functions** tab, and select **Capacitance**.

4. Press the **MENU** key.

5. Select **Settings**.

6. Set the Range to **1 nF**.

7. Press the **MENU** key.

8. Select **Calculations** and select **Rel**, then **Acquire**.

NOTE

Cabling could be as high as ≈ 300 pF, which could prevent full-scale verification due to the large cable capacitance offset. Cable lengths should be minimized to reduce cable capacitance as much as possible.

9. Connect the shielded banana cable to the 1 nF to 1 µF Decade Capacitance Box as shown in the figure below.

Figure 20: Capacitance verification connections
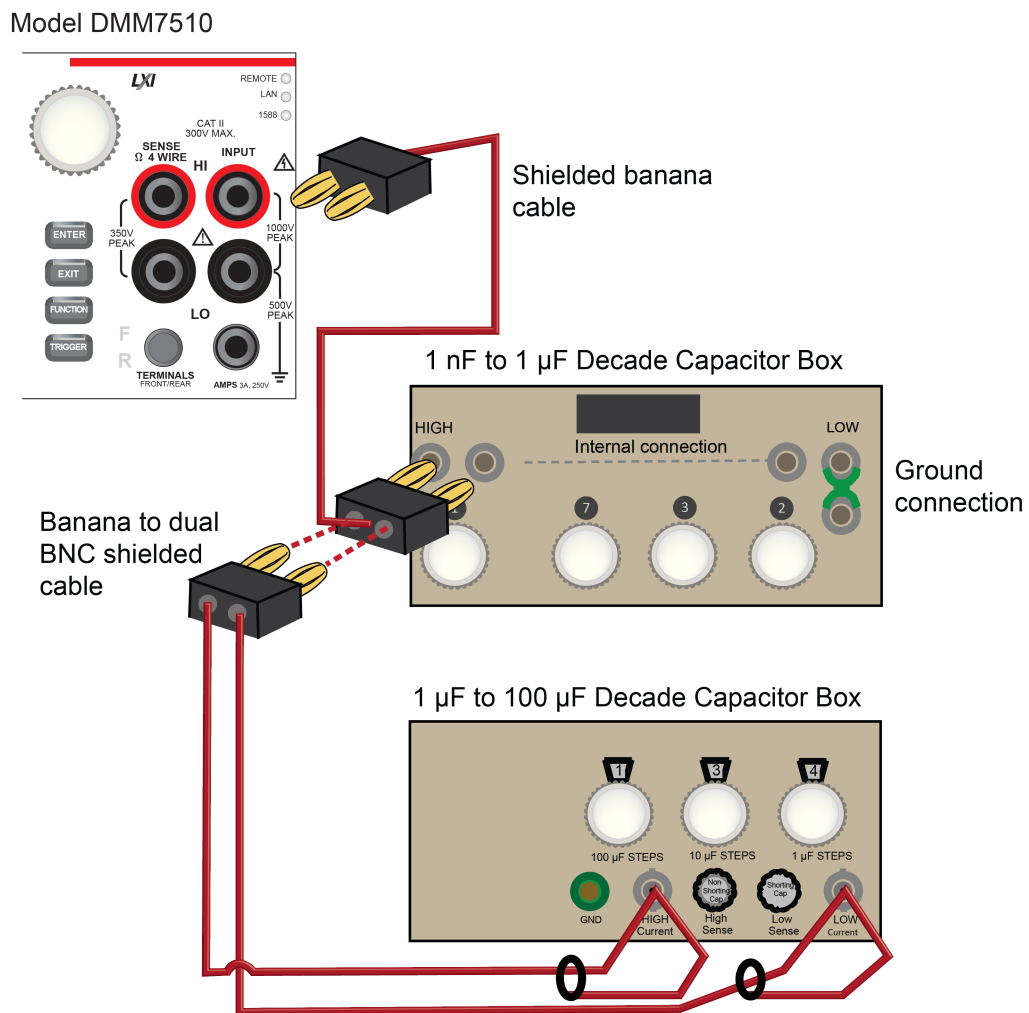
10. Verify capacitance following the verification points and accuracies from the table below.

Verify the capacitance

Description	Verification point	Lower limit (F)	Upper limit (F)
1 nF range cable REL	3.00E-10	n/a	n/a
10 % 1 nF range	1.0000E-10	9.7000E-11	1.0300E-10
70 % 1 nF range	7.0000E-10	6.9100E-10	7.0900E-10
10 % 10 nF range	1.0000E-09	9.8000E-10	1.0200E-09
100 % 10 nF range	1.0000E-08	9.8900E-09	1.0110E-08
10 % 100 nF range	1.0000E-08	9.8600E-09	1.0140E-08
100 % 100 nF range	1.0000E-07	9.9500E-08	1.0050E-07
10 % 1 µF range	1.0000E-07	9.8600E-08	1.0140E-07
100 % 1 µF range	1.0000E-06	9.9500E-07	1.0050E-06
10 % 10 µF range	1.0000E-06	9.8600E-07	1.0140E-06
100 % 10 µF range	1.0000E-05	9.9500E-06	1.0050E-05
10 % 100 µF range	1.0000E-05	9.8600E-06	1.0140E-05
100 % 100 µF range	1.0000E-04	9.9500E-05	1.0050E-04
10 % 1 mF range	1.0000E-04	9.8500E-05	1.0150E-04

Verifying zero values using a 4-wire short

NOTE

Four-wire short verifications are not included in the Customer Calibration Data Report.

To verify zero values using a 4-wire short, you will:

- Check the zero values of various test points with 4-wire connections to the Model DMM7510 front or rear terminals.
- Verify that the displayed readings are within specified limits.

Verify resistance zero values using a 4-wire short

To verify resistance zero values:

1. Select the **4W Res** function.
2. Set the Model DMM7510 to the **1Ω** range.
3. Press the **MENU** key.
4. Select **Settings**.
5. Set the Offset Compensation to **On**.
6. Connect the Model 8610 or 8620 4-wire short to the front panel as shown in the following figure.
7. Allow to settle for 5 minutes. Do not use relative offset.

Figure 21: Front panel 4-wire shorting plug orientation

Model DMM7510
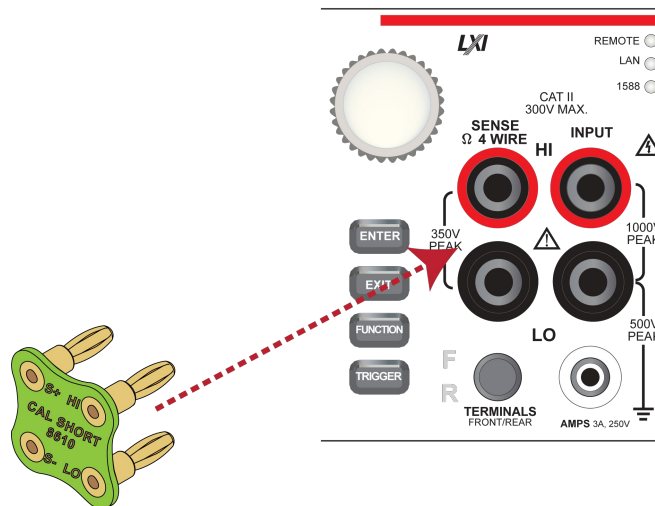
8. Verify that the 1 Ω range is within specification (see the following table).
9. Repeat verification for the 10 Ω to 100 kΩ ranges.

Verify 4-wire resistance zero values

Range (Ω)	Lower limit	Upper limit
1	–5.00E-05	5.00E-05
10	–5.00E-05	5.00E-05
100	–4.00E-04	4.00E-04
1 k	–3.00E-03	3.00E-03
10 k	–3.00E-02	3.00E-02
100 k	–3.00E-01	3.00E-01

Verify DC voltage zero values using the 4-wire short

To verify DC voltage zero values:

1. Leave the short connected as described in .
2. Press the **FUNCTION** key.
3. Select the **DC Voltage** function.
4. Press the **HOME** key.
5. Set the range to **1000 V**.

NOTE

DC voltage verification is done in descending range order, starting with the 1000 V range and finishing on the 1 V range.

6. Verify that the 1000 V range zero is within specification. See the table below.
7. Verify that the 100 V to 1 V range zero is within specification.

Verify DC Voltage zero values

Range	Lower limit	Upper limit
1000	–5.00E-03	5.00E-03
100	–5.00E-04	5.00E-04
10	–1.20E-05	1.20E-05
1	–2.00E-06	2.00E-06

Rear-panel verification

The following topics describe verification procedures that are done with connections attached to the terminals on the Model DMM7510 rear panel.

DC current 10 A range verification

To verify 10 A range:

1. Set the TERMINALS switch to **REAR**. Ensure that the orange **R** is displayed.
2. Press the **FUNCTION** key and select **DC Current**.
3. Press the **HOME** key.
4. Set the range to **10A**.
5. Connect Model DMM7510, reference DMM, calibrator, and amplifier as shown in the following figure.

⚠ CAUTION

Ensure cabling is designed to conduct 10 A without significant voltage drop. In general, cables for the 10 A range steps should be made of heavy guage wire and should be as short as practical.

Figure 22: Connections for DC current verification 10 A range
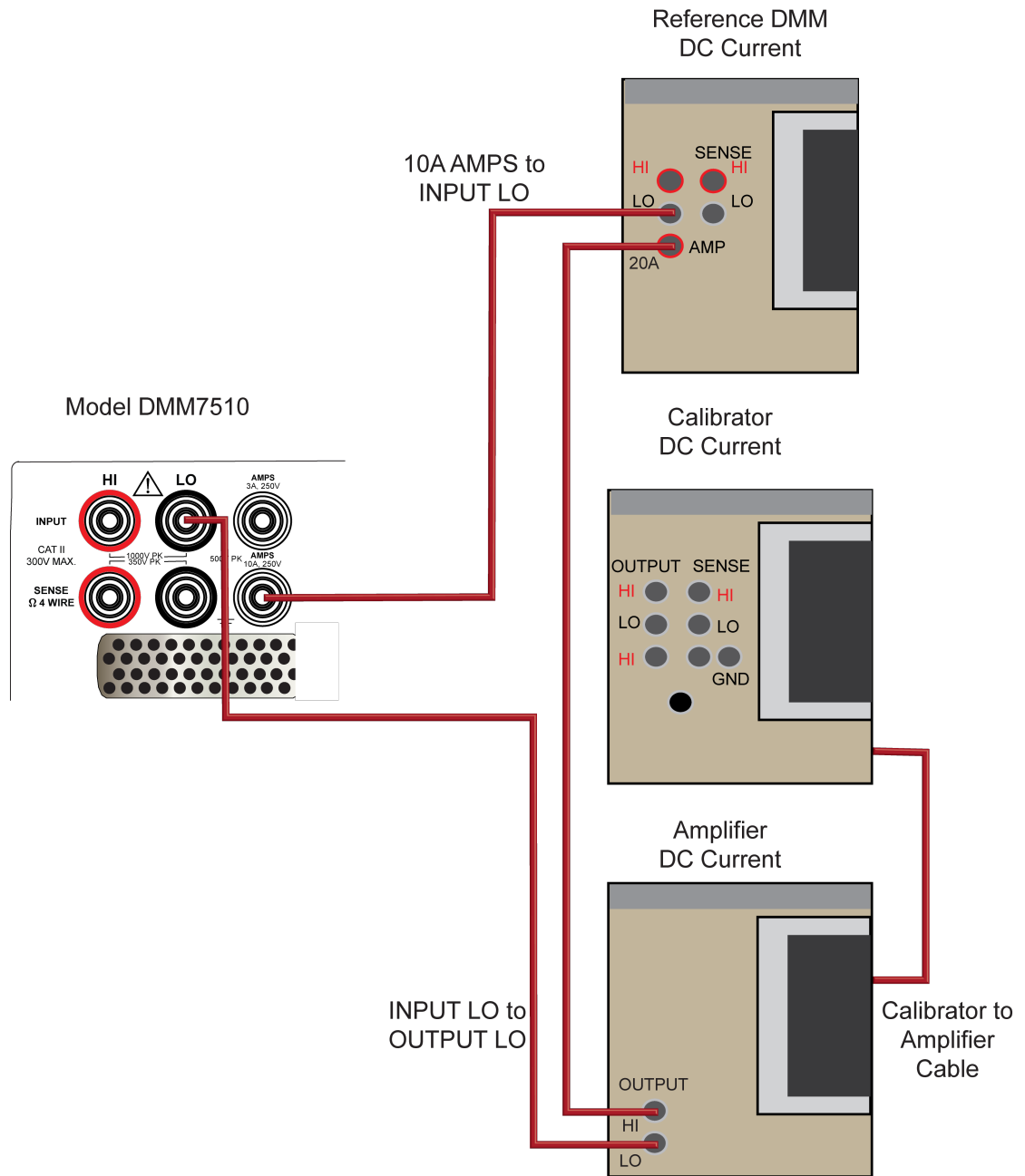
Apply a relative offset to the Model DMM7510:
1. On the calibrator, select the **OPR/STBY** key. Ensure that the front panel displays STANDBY.
2. Verify the Model DMM7510 zero reading.

Apply a relative offset to the system:
1. On the calibrator, select **OPR/STBY** key. Ensure that the front panel displays OPERATE.
2. Enable the calibrator amplifier and select the **BOOST** key.
3. On the calibrator, set the amplifier range lock **ON**.
4. Source **0.0 A**.
5. On the reference DMM, select **DCA**, **20A** range.
6. On the 20 A range, apply the reference DMM offsets using **Zero Range**.
7. On the Model DMM7510, apply the system offsets.
8. Verify the DC current verification points and reference DMM readings from the following table.

Verify DC current 10 A range

Description	Nominal input	Typical measured input (A)	Lower limit	Upper limit
UUT Zero	STANDBY		-2.750E-03	2.750E-03
System zero	0.00E+00	4.80E-04	REL	REL
Full scale (+)	10	9.99961	9.9818606E+00	1.0017359E+01
Half scale (+)	5	4.99984	4.9895902E+00	5.0100898E+00
Half scale (−)	−5	−5.00079	−5.0110412E+00	−4.9905388E+00
Full scale (−)	−10	−10.0016	−1.0019352E+01	−9.9838476E+00

Digitize current 10 A range verification

⚠ **CAUTION**

Ensure cabling is designed to conduct 10 A without significant voltage drop. In general, cables for the 10 A range steps should be made of heavy guage wire and should be as short as practical.

To verify the 10 A range:

1. Connect Model DMM7510, calibrator, and amplifier as shown in the following figure.

Figure 23: Connections for the 10 A range
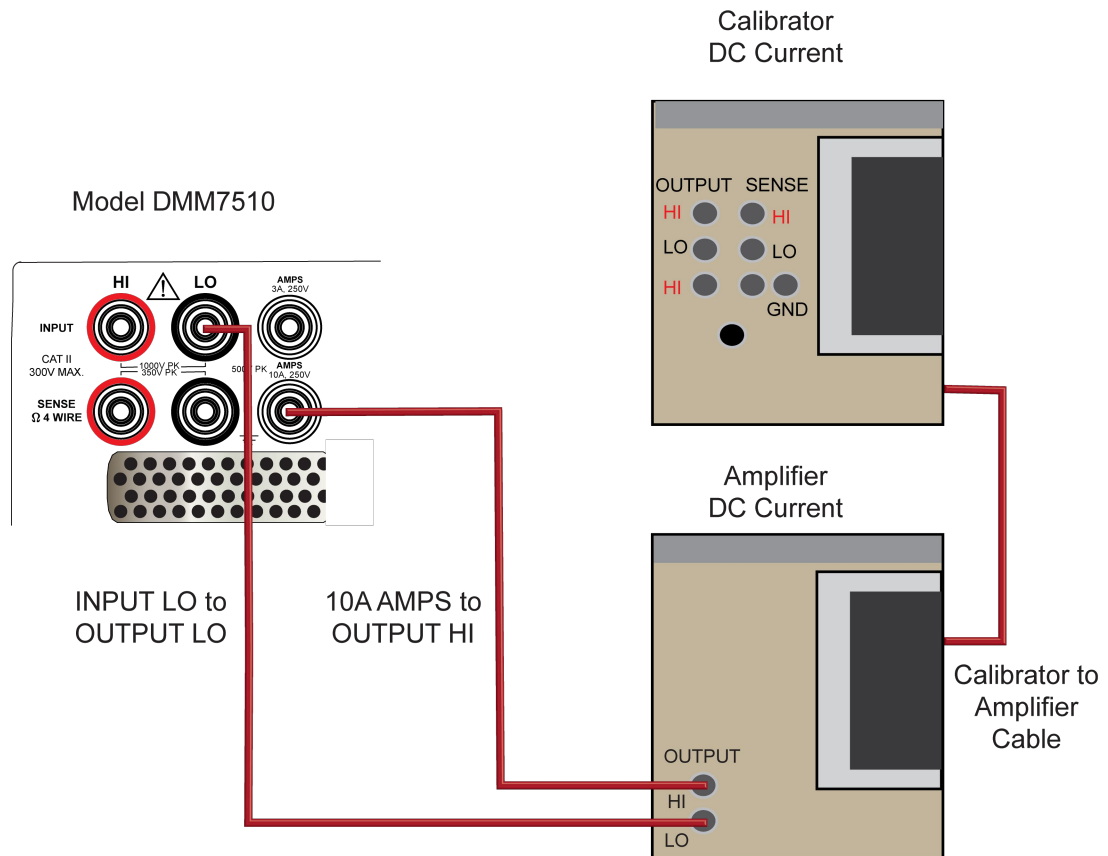
⚠ **CAUTION**

Ensure cabling is designed to conduct 10 A without significant voltage drop. In general, cables for the 10 A range steps should be made of heavy guage wire and should be as short as practical.

2. Set the TERMINALS switch to **REAR**. Ensure that the orange **R** is displayed.
3. Press the **FUNCTION** key, select the **Digitize Functions** tab, and select **Digitize Current**.
4. Press the **HOME** key.
5. Set the range to **10A**.
6. Press the **MENU** key.

7. Select **Settings**.
8. Set the sample rate to **1000**.
9. Set the aperture to **Auto** or **1 ms**.
10. Set the count to **100**.

Verify the Model DMM7510 zero:

1. On the calibrator, select the **OPR/STBY** key. Ensure that the front panel displays STANDBY.
2. Verify the Model DMM7510 zero reading for each range.

Apply a relative offset to the system:

1. On the calibrator, select the **OPR/STBY** key. Ensure that the front panel displays OPERATE.
2. Enable the calibrator Amplifier and select the **BOOST** key.
3. On the calibrator, set the amplifier range lock **ON**.
4. Set the calibrator output to **0.00000 ADC** and allow the reading to settle.
5. Press the **MENU** key.
6. Select **Calculations**.
7. Select **Rel** and **Acquire**.
8. Source positive and negative full-scale and half-scale currents, as listed in the following table.
9. Verify that the STATISTICS swipe screen reading for average is within low and high limits.

Verify digitize current 10 A range

Description	Calibrator setpoint (A)	Lower limit	Upper limit
UTT Zero	STANDBY	−3.50E-03	3.50E-03
Full scale (+)	10	9.98150E+00	1.00185E+01
Half scale (+)	5	4.98900E+00	5.01100E+00
Half scale (−)	−5	−5.01100E+00	−4.98900E+00
Full scale (−)	−10	−1.00185E+01	−9.98150E+00

AC current 10 A verification

Verify that the displayed readings are within specified limits.

Use the values in the tables following the steps below to verify the performance of the Model DMM7510. Actual values depend on the published specifications (see Example reading limit calculation (on page 2-7)).

To verify the AC current accuracy:

1. Set the TERMINALS switch to **REAR**. Ensure that the orange **R** is displayed.
2. Press the **FUNCTION** key, select the **Measure Functions** tab, and select **AC Current**.
3. Press the **HOME** key.
4. Set the range to **10A**.
5. Press the **MENU** key.
6. Select **Settings**.
7. Ensure that detector bandwidth is set to **30 Hz**.

NOTE

AC current is specified for the detector bandwidth setting of 3 Hz. 3 Hz measures accurately for input signals from 3 Hz to 10 kHz, with reading rates of ≈ 0.5 readings/s. To improve verification throughput to ≈ 3.3 readings/s, set detector bandwidth to 30 Hz for frequencies of 30 Hz to 10 kHz. To verify frequencies 1 kHz and higher, set the detector bandwidth to 300 Hz for faster ≈ 55 readings/s throughput.

8. Connect the Model DMM7510 to the calibrator and amplifier as shown in the following figure.

⚠ CAUTION

Ensure cabling is designed to conduct 10 A without significant voltage drop. In general, cables for the 10 A range steps should be made of heavy guage wire and should be as short as practical.

Figure 24: Connections for the 10 A range
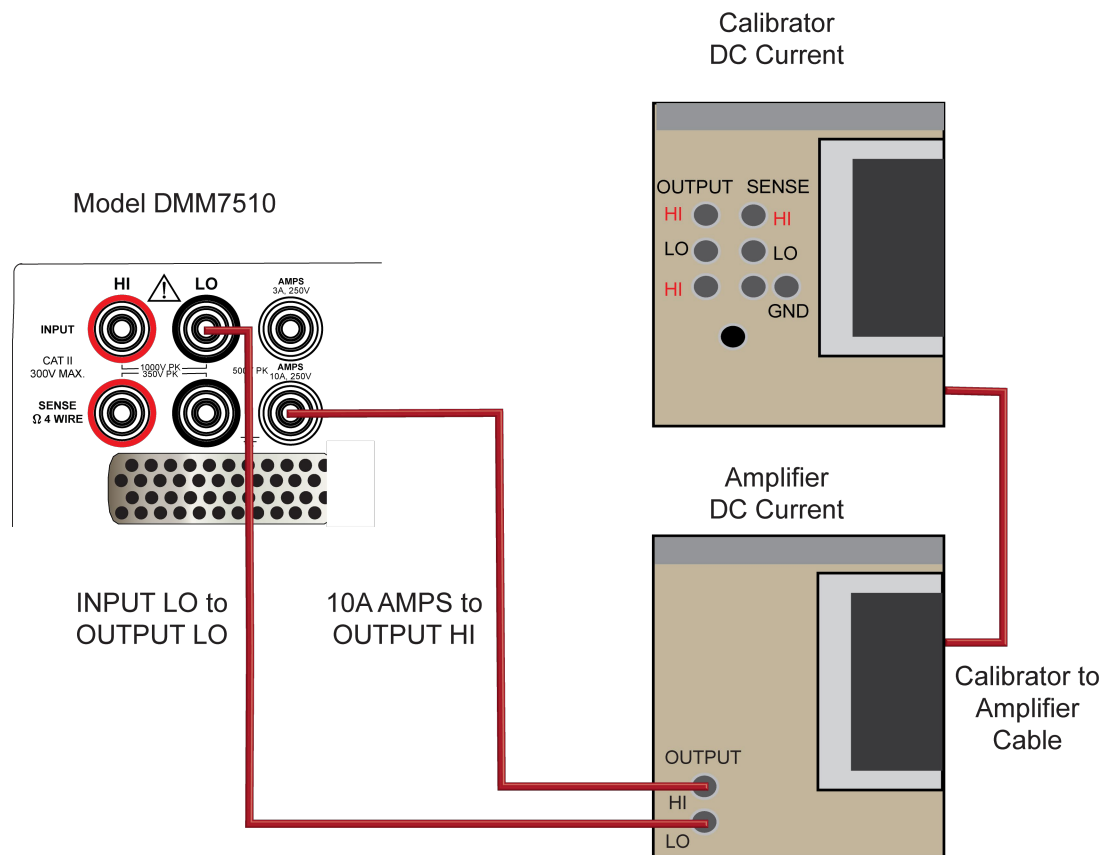
9. Enable the calibrator amplifier and select the **BOOST** key.
10. On the calibrator, set the amplifier range lock **ON**.
11. Source AC current for each of the frequencies listed in the following table.
12. On the calibrator, select **OPR/STBY** key. Ensure that the front panel displays OPERATE.
13. For each setting, allow the calibrator and amplifier to settle properly and verify the reading is within low and high limits.

Verify AC current 10 A range

Description	Verification point	Lower limit	Upper limit
40 Hz	10.000	9.955000E+00	1.004500E+01
1 kHz	10.000	9.955000E+00	1.004500E+01
5 kHz	10.000	9.907000E+00	1.009300E+01

Adjustment

In this section:

Introduction

Use the procedures in this section to adjust the Model DMM7510 calibration.

Model DMM7510 performance is specified for a period of 90 days, 1 year, or 2 years from adjustment. Adjustment should be performed at one of these intervals, depending on your specification requirements.

NOTE

Enhanced accuracy specifications require that autocalibration be performed within the last 30 days, or whenever the internal temperature has shifted more than 5 °C from the last autocalibration. For more information, see Autocalibration (on page 2-4).

Performance is also specified relative to calibration adjustment temperature (Tcal). Keithley factory adjustment is performed at 23 °C ± 1 °C.

⚠ 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 appropriate safety precautions when working with hazardous voltages.

Environmental conditions

To ensure accurate results, the environment must meet the following conditions.

Temperature and relative humidity

Conduct the adjustment procedures in a test environment with:

- A stable ambient temperature controlled to vary less than ±1 °C during the period of adjustment.
- Keithley Instruments recommends a calibration adjustment temperature (T_{cal}) of 23 °C. If a different nominal temperature is used, it should be noted on the calibration report.
- A relative humidity of less than or equal to 40 percent, unless otherwise noted.
- No direct airflow on the input terminals.

Line power

The Model DMM7510 requires a line voltage of 100 V to 240 V and a line frequency of 50 Hz or 60 Hz.

The instrument must be adjusted within this range.

NOTE
The instrument automatically senses the line frequency at power-up.

Warmup period

Allow the Model DMM7510 to warm up for at least 90 minutes before conducting the adjustment procedures.

If the instrument has been subjected to temperature extremes (more than 5 °C (9 °F) above T_{cal}), allow additional time for the internal temperature of the instrument to stabilize. Typically, allow an additional hour to stabilize an instrument that is 10 °C (18 °F) outside the specified temperature range.

Also, allow the test equipment to warm up for the amount of time recommended by the manufacturer.

Adjustment overview

Model DMM7510 adjustment is performed using a remote connection through either a GPIB, LAN, or USB interface. The calibration adjustment commands provided in this manual use the Test Script Processor (TSP®) command language. There is no front-panel method for full adjustment.

During adjustment, the Model DMM7510 calibrates its internal references to external standards. All DC and digitize voltage and current (below the 10 A range), and all resistance adjustments are derived from measurements of four standard reference signals:

- 4-wire shorted input
- +10 V
- -10 V
- 10 kΩ

Other adjustment steps calibrate:

- Open input capacitance and bias currents
- 10 A range high-current functions
- AC gain and frequency compensation, range by range
- Internal frequency reference

Recommended test equipment

The following table summarizes the recommended calibration equipment. Specified accuracy of all functions and ranges is dependent on the precision of reference signals used during the adjustment process. To achieve specified performance, adjustment reference uncertainties must be at least four times smaller than the best corresponding Model DMM7510 one-year accuracy specification for measuring that signal.

Manufacturer	Model	Description	Used for:
Fluke	5720A or 5730A	High Performance Multifunction Calibrator	DCV, 10 A DCI, ACV, ACI, and 10 kΩ resistance
Fluke	5725A	Amplifier	DCI and ACI 10 A ranges
Fluke	8508A	8.5 Digit Reference Multimeter	DCV
Keithley Instruments	3390	Function/Arbitrary Waveform Generator	Frequency
Keithley Instruments	8610 or 8620	4-Wire DMM Shorting Plug	DCV, digitize DCV, and resistance

NOTE

Refer to the manufacturer's specifications to calculate the uncertainty, which varies for each function and range test point.

General adjustment considerations

• Model DMM7510 DCV performance is sensitive to errors from thermoelectric potentials generated by test cables and connections. Be sure to use high-quality cables and connection techniques. When changing a connection during the adjustment process, be sure to allow time (up to five minutes) for thermal settling. Also allow thermal settling time when changing the Front/Rear switch position during adjustment.

• Calibration steps are performed on both rear and front inputs as described in sections below, except for Model DMM7510-NFP (no front panel; all adjustment steps use rear inputs). Be sure that the Front/Rear switch is in the proper position before sending adjustment commands.

• The Keithley Models 8610 and 8620 4-wire shorts connect all four terminals electrically, but the layout of the board traces makes Model DMM7510 adjustment sensitive to their orientation. Note the HI/LO terminal markings and be sure to insert connections in the correct orientation. Note that the Model DMM7510 rear input terminals are rotated 90° compared to front-panel inputs.

• During adjustment steps using a calibrator reference source, be sure the calibrator reference signal has fully settled before sending adjustment commands to the Model DMM7510.

⚠ WARNING

The front and rear terminals of the instrument are rated for connection to circuits rated Measurement Category II up to 300 V, as described in International Electrotechnical Commission (IEC) Standard IEC 60664. This range must not be exceeded. Do not connect the instrument terminals to CAT III or CAT IV circuits. Connection of the instrument terminals to circuits higher than CAT II can cause damage to the equipment and severe personal injury.

The maximum input voltage between INPUT HI and INPUT LO is 1000 V$_{PEAK}$. Exceeding this value may result in instrument damage.

The maximum input voltage between INPUT HI and INPUT LO is 1000 V$_{PEAK}$. Exceeding this value may create a shock hazard.

The maximum common-mode voltage (the voltage between INPUT LO and chassis ground) is 500 V$_{PEAK}$. Exceeding this value may cause a breakdown in insulation that can create a shock hazard.

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 appropriate safety precautions when working with hazardous voltages.

Initial instrument setup

Before adjusting calibration, make sure that the instrument is set up:

• To use the rear terminals.

• For remote operation and TSP commands.

• To the correct date and time.

You must also unlock calibration.

Select the correct terminals

On the Model DMM7510, you must adjust calibration from both the front and rear terminals. You can verify calibration on either the front or rear terminals. To set the instrument to the rear-panel terminals, press the FRONT/REAR TERMINALS switch on the front panel of the instrument until **R** is lit next to the switch.

Select the TSP command set

Calibration adjustment must be performed by remote control using LAN, GPIB, or USB interfaces. No front-panel calibration commands are available.

Calibration is only available using TSP commands. See the instructions below to change the command set.

To set the command set from the front panel:
1. Press the **MENU** key.
2. Under System, select **Settings**.
3. For Command Set, select **TSP**.
4. You are prompted to reboot.

To verify which command set is selected from a remote interface:

Send the command:
```
*LANG?
```

To change to the TSP command set from a remote interface:

Send the command:
```
*LANG TSP
```

Reboot the instrument.

Verify instrument date and time

Before adjusting calibration, verify the system date of the Model DMM7510.

From the front panel:
1. Press the **MENU** key.
2. Under System, select Settings. The SYSTEM SETTINGS menu opens.
3. Verify the date and time.
4. If necessary, correct the date and time.

Set up remote connections

NOTE

For detail on remote communications, refer to the *Model DMM7510 Reference Manual* section "Remote communications interfaces."

Calibration adjustment is performed by connecting reference signals to the Model DMM7510 and sending a series of adjustment commands using one of the remote interfaces. The adjustment procedure may be done interactively, programmatically, or using a combination of the two.

- **Interactive:** Manually set up and connect each reference signal, then send the appropriate calibration adjustment command. Observe the Model DMM7510 display for progress indicators and error messages before performing the next step.

- **Programmatic:** A computer performs setup of calibrator source instruments and controls appropriate settling delays before automatically sending calibration adjustment commands to the Model DMM7510. The control program must determine when the adjustment step is complete and check for adjustment errors before continuing to the next step.

The following section describes only the essential Model DMM7510 adjustment commands that are used for a manual interactive adjustment procedure. Techniques for controlling automated program timing and error checking are described in Adjustment command timing and error checking (on page 3-20).

Unlock calibration

To adjust calibration, you must unlock it by sending the calibration password:

```
cal.unlock("KI000CAL")
```

NOTE

KI000CAL is the default password. You can change the password. Refer to cal.password (on page 4-17) for details.

Remote calibration adjustment procedures

NOTE

During remote calibration adjustment, the front-panel display shows the calibration adjustment step with a status progress bar.

Example calibration adjustment code that provides additional front-panel display prompts is provided in Example calibration adjustment code (on page 3-23).

Rear-terminal adjustment steps

Follow the steps described in this section to adjust the Model DMM7510 using the rear terminals.

Summary of rear-terminal adjustment steps:

- Prepare the Model DMM7510 for rear-terminal adjustment
- DC step 0: Internal amplifier offset adjustment
- DC step 1: 4-wire zero, DCI 10 A, DCV, digitize DCV, 2W Ω, and 4W Ω
- DC step 2: Open terminals, capacitance
- DC step 3: 2 A, DCI 10 A range

- AC current step 1: 0.5 A 1 kHz, AC current 10 A range zero
- AC current step 2: 2 A to 10 A 1 kHz, AC current 10 A range full-scale

See the following topics for detailed instructions.

Prepare the Model DMM7510 for rear-terminal adjustment

To prepare the Model DMM7510 for rear-terminal adjustment:

1. Set the TERMINALS switch to **REAR**. Ensure that the orange **R** is displayed.
2. Install the Keithley Model 8610 or 8620 shorting plug on the rear terminals of the Model DMM7510 as shown in the figure below.

> ## ⚠ CAUTION
>
> The shorting plug terminals must be connected so that HI and LO are correctly aligned. Zero accuracy will be affected if the shorting plug terminals are not aligned correctly.

Figure 25: Rear panel 4-wire shorting plug orientation

Model DMM7510
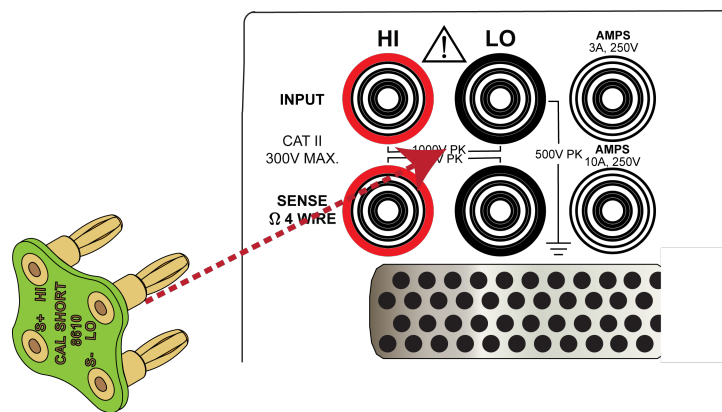
3. Allow the instrument to settle for five minutes.

Rear DC adjustment step 0: Amplifier offset

Send the command:
```
cal.adjust.rear.dc(0)    -- Supports either 4-wire short or open terminals.
```

Rear DC adjustment step 1: 4-wire zero

Send the command:
```
cal.adjust.rear.dc(1)  -- Requires 4-wire short.
```

Rear DC adjustment step 2: Open circuit

To run rear DC adjustment step 2:

1. Remove the 4-wire short from the inputs.

NOTE

Cables cannot be attached to the Model DMM7510 during this step. At the beginning of this step, the HI and LO terminals are measured for applied voltage detection. If detected, the step will terminate, generating a warning message. Also, any attached cables will significantly impact accuracy or cause the adjustment step to fail.

Figure 26: Rear-panel terminals open
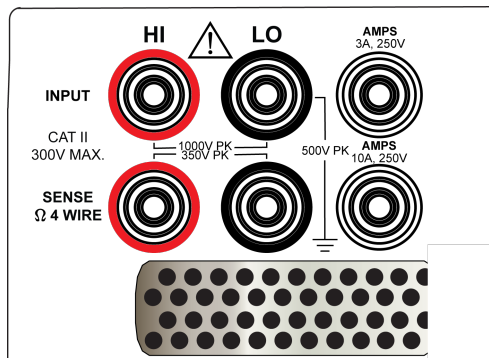
2. Send the command:

```
cal.adjust.rear.dc(2)  -- Requires open rear terminals.
```

Rear DC adjustment step 3: DCI 10 A full-scale adjustment

To run rear DC adjustment step 3:

1. Connect the calibrator and Model DMM7510 as shown in the following figure.

Figure 27: Rear DC step 3 calibrator and Model DMM7510 connections
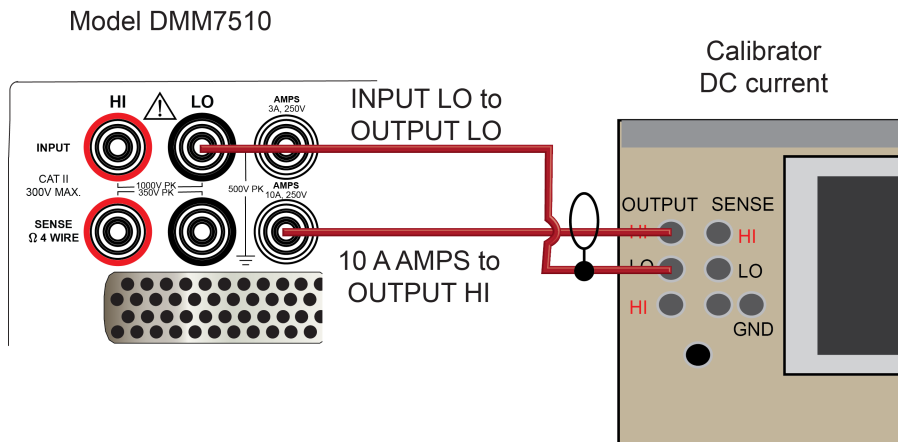
2. Ensure that the calibrator current output is set to **Normal**.

3. On the calibrator, set the source to **2.0 A**. Note that calibration adjustment step 3 allows 2 A ±10 % for the source level.

4. Allow the calibrator to settle properly.

5. Enter the actual calibrator output value from step 3 (if not exactly 2.0 A).

Send the command:

```
cal.adjust.rear.dc(3, 2.0)   -- Requires the calibrator to source 2A.
```

Rear AC adjustment step 1: ACI 10 A Zero adjustment

To run rear AC adjustment step 1:

1. Maintain the connections from Rear DC adjustment step 3: DCI 10 A full-scale adjustment (on page 3-8).

2. On the calibrator, set the level to **0.5 A** at **1 kHz**.

NOTE
The 0.5 A source value is required. If an alternate value is used, incorrect accuracies will occur and possibly out of tolerance warning messages.

3. On the calibrator, select **OPR/STBY** key. Ensure that the front panel displays OPERATE.

4. Allow the calibrator to settle properly.

5. Send the following command.

```
cal.adjust.rear.ac(1)   -- Requires calibrator to source 0.5 A AC at 1 KHz into 10 A
   and Lo rear terminals.
```

Rear AC adjustment step 2: ACI 10 A full-scale adjustment

To run rear AC adjustment step 2:

1. Connect the calibrator, amplifier, and Model DMM7510 as shown in the following figure.

⚠ CAUTION
Ensure cabling is designed to conduct 10 A without significant voltage drop. In general, cables for the 10 A range steps should be made of heavy guage wire and should be as short as practical.

Figure 28: Connections for the 10 A range
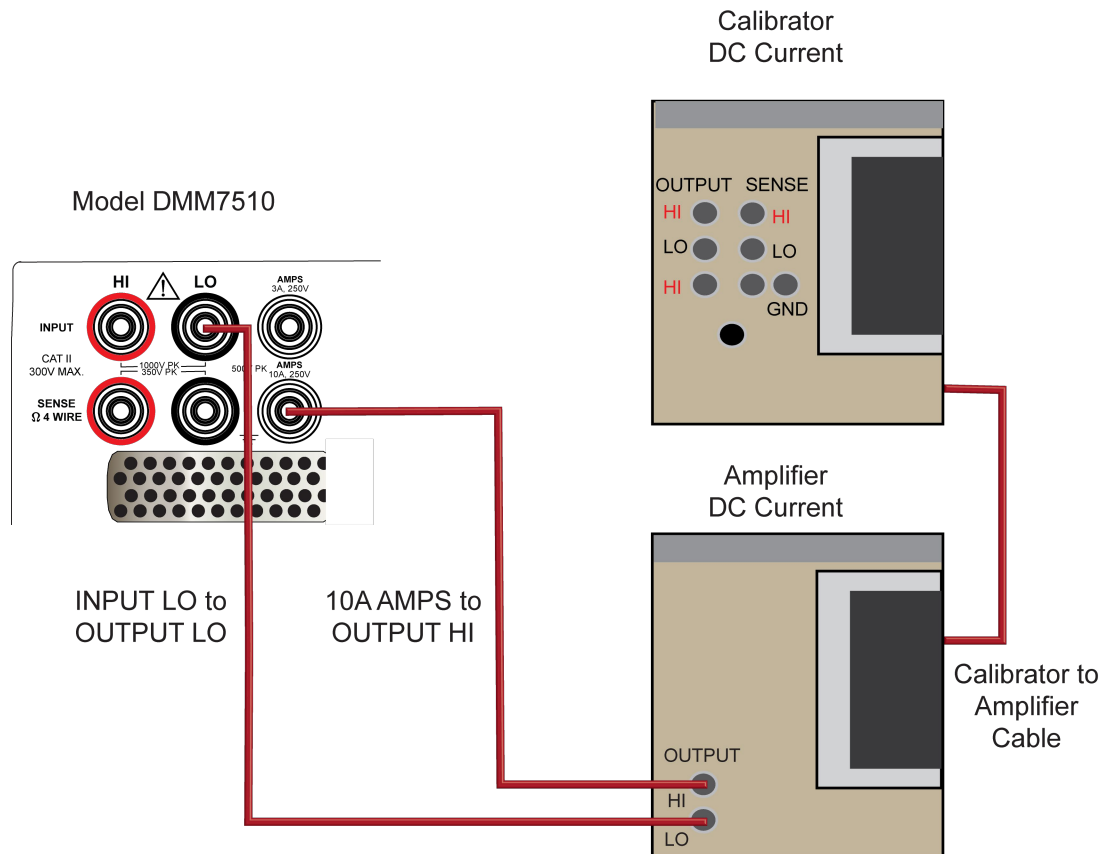
2. On the calibrator, set the level to **7 A at 1 kHz**.

NOTE

Calibration adjustment step 2 allows 2 A through 10 A, ±10 % for the source level. It is best to use 7 A for lowest full-scale uncertainty and minimize internal thermal settling.

3. Enable the calibrator amplifier and select the **BOOST** key.
4. On the calibrator, set the amplifier range lock **ON**.
5. On the calibrator, select **OPR/STBY** key. Ensure that the front panel displays OPERATE.
6. Allow the calibrator and amplifier to settle properly.
7. Send the following command.

```
cal.adjust.rear.ac(2, 7.0)  --  Requires Fluke Model 5720/5725 to source 7.0A ac at
    1KHz into 10A and Lo rear terminals.
```

Front-terminal adjustment steps

Follow the steps described in this section to adjust the Model DMM7510 using the terminals on the Model DMM7510 front panel.

Summary of front-terminal adjustment steps:

- DC adjustment (`cal.adjust.dc()`)
  - DC step 0: Internal amplifier offset adjustment
  - DC step 1: 4-wire zero for DCI 1 A to 3 A, DCV, digitize DCV, 2W Ω, and 4W Ω
  - DC step 2: Open terminals
    - DCI, zero 10 µA to 100 mA
    - DCV, 100 V and 1000 V full-scale
    - Resistance, 1 Ω to 1 GΩ full-scale
    - Digitize DCI and DCV full-scale
    - Waveform, analog trigger
    - Frequency, threshold level trigger
  - DC step 3: 10 V, DCV 10 V range
  - DC step 4: -10 V, DCV 10 V range
  - DC step 5: 10 kΩ, resistance, 4W 10 kΩ range

- ACV adjustment (`cal.adjust.ac()`)
  - ACV step 1, 10 mV 1 kHz, ACV 100 mV range 10 percent of range
  - ACV step 2, 100 mV 1 kHz, ACV 100 mV range full-scale and 1 V range zero
  - ACV step 3, 100 mV 50 kHz, ACV 100 mV frequency flatness adjustment
  - ACV step 4, 1 V 1 kHz, ACV 1 V range full-scale and 10 V range zero
  - ACV step 5, 1 V 50 kHz, ACV 1 V range frequency flatness adjustment
  - ACV step 6, 10 V 1 kHz, ACV 10 V range full-scale and 100 V range zero
  - ACV step 7, 10 V 50 kHz, ACV 10 V range frequency flatness adjustment
  - ACV step 8, 100 V 1 kHz, ACV 100 V range full-scale and 700 V range zero
  - ACV step 9, 100 V 50 kHz, ACV 100 V range frequency flatness adjustment
  - ACV step 10, 700 V 1 kHz, ACV 700 V range full-scale

- ACI adjustment (`cal.adjust.ac()`)
  - ACI step 11, 100 µA 1 kHz, ACI 1 mA range zero
  - ACI step 12, 1 mA 1 kHz, ACI 1 mA range full-scale and 10 mA range zero
  - ACI step 13, 10 mA 1 kHz, ACI 10 mA range full-scale and 100 mA range zero
  - ACI step 14, 100 mA 1 kHz, ACI 100 mA range full-scale, 1 A and 3 A range zero
  - ACI step 15, 1 A 1 kHz, ACI 1 A range full-scale
  - ACI step 16, 2 A 1 kHz, ACI 3 A range full-scale

- AC-coupling amplitude adjustment
  - ACV step 17, 1 V 10 Hz, ACV AC coupling amplitude adjustment

- Frequency adjustment (requires value parameter for frequency in Hertz)
  - ACV step 18, 1 V 1 kHz, squarewave, frequency adjustment

Prepare the Model DMM7510 for DCV adjustment steps 0 to 2

To prepare the Model DMM7510 for DCV adjustment steps 0 to 2:

1. Set the TERMINALS switch to **FRONT**. Ensure that the green **F** is displayed.
2. Install the Keithley Model 8610 or 8620 shorting plug on the front terminals of the Model DMM7510 as shown in the figure below.

Figure 29: Front panel 4-wire shorting plug orientation

Model DMM7510
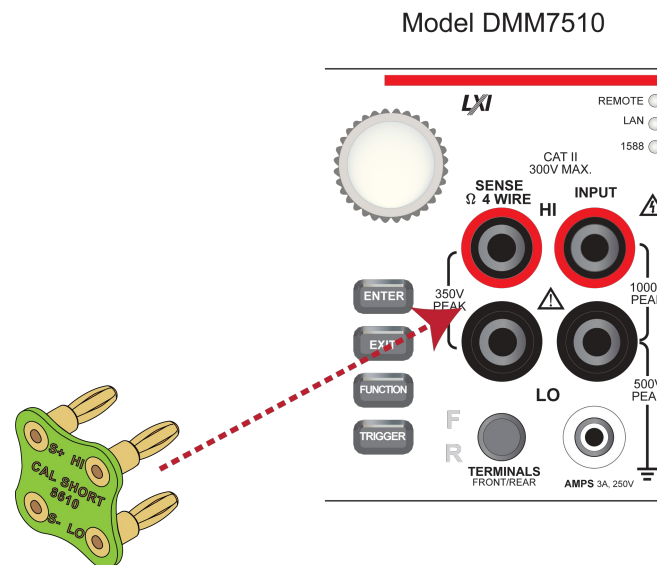
3. Allow to settle for five minutes.

DC voltage adjustment step 0: MUX amp offset

Send the command:

```
cal.adjust.dc(0)   -- Supports either 4-wire short or open terminals.
```

DC voltage adjustment step 1: Input 4-wire short circuit

Send the command:

```
cal.adjust.dc(1)   -- Requires 4-wire short.
```

DC voltage adjustment step 2: Open circuit

NOTE

DC adjustment step 2 can be run with attached cables if there is no applied voltage. Because open-circuit DC adjustment step 2 requires approximately seven minutes to complete, you can preconnect cables to allow subsequent adjustment steps to run without additional thermal settling delays.

To run DCV adjustment step 2:

1. Remove the four-wire short from the inputs.
2. Optional: Connect calibrator cables for later adjustment steps.
3. Send the command:

```
cal.adjust.dc(2)   -- Requires open circuit at input.
```

Prepare the Model DMM7510 for DCV adjustment steps 3 to 5

To prepare to run DCV adjustment steps 3, 4, and 5:

1. Connect a cable between the calibrator and the Model DMM7510 as shown in the figure below.

Figure 30: Connections for DC voltage accuracy adjustment steps 3 to 5
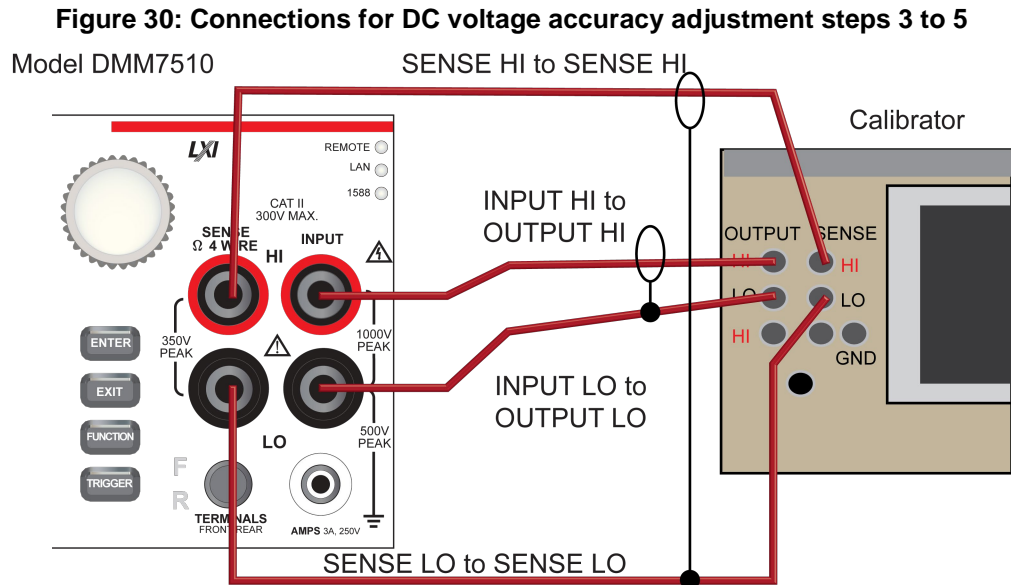
2. Allow the instrument and cable to settle for five minutes (if cables were not attached at DCV step 2).

To run DCV adjustment step 3:

1. Source **+10 V** and allow the calibrator to settle properly.
2. Ensure that the calibrator output is enabled.
3. Send the command:

```
cal.adjust.dc(3, 10.0)  -- 10 V require HI and LO front terminals.
```

NOTE

For `cal.adjust.dc(3, <v10>)`, the `<v10>` parameter may be ±10 percent, depending on the actual applied voltage.

To run DC adjustment step 4:

1. Source **-10 V** and allow the calibrator to settle properly.
2. Ensure that the calibrator output is enabled.
3. Send the command:

```
cal.adjust.dc(4, -10.0)    -- -10 V requires HI/LO front terminals.
```

NOTE

For `cal.adjust.dc(4, <v-10>)`, the `<v-10>` parameter may be -10 V ± 10 percent, depending on the applied voltage.

DC voltage adjustment step 5: 10 kΩ

To run DCV adjustment step 5:

1. Retain the connections made in <u>Prepare the Model DMM7510 for DCV adjustment steps 3 to 5</u> (on page 3-13).

2. Allow the instruments and cables to settle for 5 minutes.

3. On the calibrator, enable the **OPR** key and the **EX SNS** key.

4. Ensure that the **OPERATE** display and **EX SNS** keys are illuminated.

5. Source **10 kΩ** and allow the calibrator and Model DMM7510 to settle properly.

6. Send the command:

```
cal.adjust.dc(5, 9.999938e3)  -- 10 Kohm requires HI and LO and 4W SHI and SLO
   front terminals. Enter the actual calibrator source value.
```

NOTE

For `cal.adjust.dc(5, <R10k>),` the `<R10k>` parameter may be 10E3 ± 10 percent, depending on the actual connected resistance.

NOTE

The Fluke 5720 calibrator supports only approximately 10 kΩ. As a valid alternative, you can use a stable external low-drift characterizer reference resistor.

Prepare the Model DMM7510 for ACV adjustment steps 1 to 10

To prepare to run AC adjustment steps 1 to 10:

1. Connect a cable between the calibrator and the Model DMM7510 as shown in the figure below (if not already connected from previous steps).

Figure 31: Connections for ACV adjustment steps 1 to 10
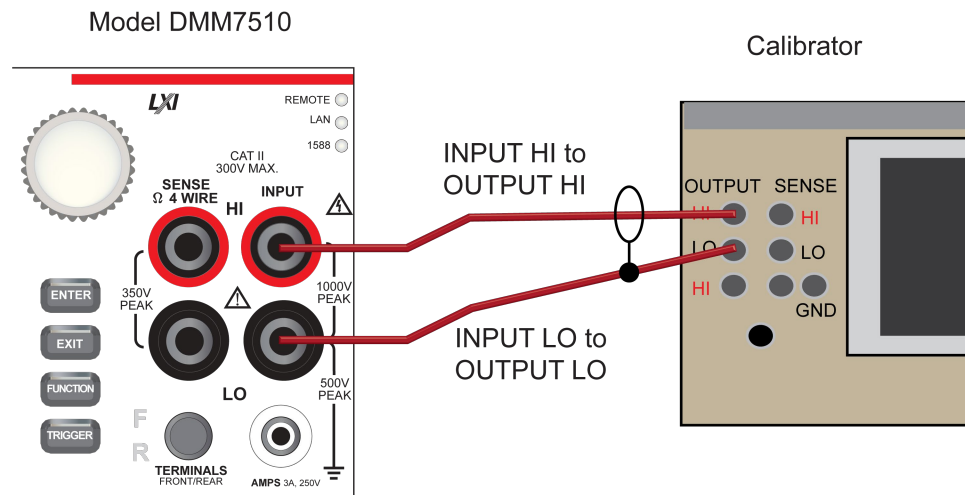
2. Allow the instrument and cables to settle for 30 seconds.
3. On the calibrator, source **10 mV 1.0 kHz**.
4. Enable the **OPR** key.

<div style="background:#6b7db5;color:white;text-align:center;">NOTE</div>

For `cal.ac.adjust` steps 1 to 16, the identified source values are required. If alternate values are used, incorrect accuracies will occur and you may get out-of-tolerance warning messages.

5. Ensure that the **OPERATE** display is illuminated.
6. Allow the calibrator and cable to settle properly.

AC voltage adjustment step 1: 10 mV at 1 kHz

Send the command:

```
cal.adjust.ac(1)        -- 10 mV, 1 KHz HI and LO front terminals.
```

AC voltage adjustment step 2: 100 mV at 1 kHz

To run ACV adjustment step 2:

1. On the calibrator, source **100 mV** at **1.0 kHz**.
2. Allow the calibrator and cable to settle properly.
3. Send the command:

```
cal.adjust.ac(2)   -- 100 mV, 1 KHz HI and LO front terminals.
```

AC voltage adjustment step 3: 100 mV at 50 kHz

To run ACV adjustment step 3:

1. On the calibrator, source **100 mV** at **50 kHz** and allow the calibrator and cable to settle properly.
2. Send the command:

```
cal.adjust.ac(3)        -- 100 mV, 50 KHz HI and LO front terminals.
```

AC voltage adjustment step 4: 1 V at 1.0 kHz

To run ACV adjustment step 4:

1. On the calibrator, source **1 V** at **1.0 kHz**.
2. Allow the calibrator and cable to settle properly.
3. Send the command:

```
cal.adjust.ac(4)        -- 1 V, 1 KHz HI and LO front terminals.
```

AC voltage adjustment step 5: 1 V at 50 kHz

To run ACV adjustment step 5:

1. On the calibrator, source **1 V** at **50 kHz**.
2. Allow the calibrator and cable to settle properly.
3. Send the command:

```
cal.adjust.ac(5)          -- 1 V, 50 KHz HI and LO front terminals.
```

AC voltage adjustment step 6: 10 V at 1.0 kHz

To run ACV adjustment step 6:

1. On the calibrator, source **10 V** at **1 kHz**.
2. Allow the calibrator and cable to settle properly.
3. Send the command:

```
cal.adjust.ac(6)          -- 10 V, 1 KHz HI and LO front terminals.
```

AC voltage adjustment step 7: 10 V at 50 kHz

To run ACV adjustment step 7:

1. On the calibrator, source **10 V** at **50 kHz**.
2. Allow the calibrator and cable to settle properly.
3. Send the command:

```
cal.adjust.ac(7)          -- 10 V, 50 KHz HI and LO front terminals.
```

AC voltage adjustment step 8: 100 V at 1.0 kHz

⚠ WARNING

The following calibration steps are intended for qualified service personnel only. Do not attempt these procedures unless you are qualified to do so. The following procedures require hazardous voltages, which could cause personal injury or death if contacted. Use appropriate safety precautions when working with hazardous voltages.

To run ACV adjustment step 8:

1. On the calibrator, source **100 V** at **1 kHz**.
2. Enable the **OPR** key.
3. Allow the calibrator and cable to settle properly.

4. Send the command:

```
cal.adjust.ac(8)          -- 100 V, 1 KHz HI and LO front terminals.
```

AC voltage adjustment step 9: 100 V at 50 kHz

To run ACV adjustment step 9:

1. On the calibrator, source **100 V** at **50 kHz**.
2. Enable the **OPR** key.
3. Allow the calibrator and cable to settle properly.
4. Send the command:

```
cal.adjust.ac(9)          -- 100 V, 50 KHz HI and LO front terminals.
```

AC voltage adjustment step 10: 700 V at 1.0 kHz

To run ACV adjustment step 10:

1. On the calibrator, source **700 V** at **1 kHz**.
2. Enable the **OPR** key.
3. Allow the calibrator and the cable to settle properly.
4. Send the command:

```
cal.adjust.ac(10)         -- 700 V, 1 KHz HI and LO front terminals.
```

Prepare the Model DMM7510 for ACI adjustment steps 11 to 16

To prepare the Model DMM7510 for ACI adjustment steps 11 to 16:

Connect the Model DMM7510 to the calibrator as shown in the following figure.

Figure 32: Connections for AC current verification

AC current adjustment step 11: 100 µA at 1 kHz

To run ACI adjustment step 11:

1. Ensure that the calibrator current output is set to **Normal**.
2. On the calibrator, source **100 µA** at **1 kHz**.
3. Enable the **OPR** key.
4. Allow the calibrator and cable to settle properly.
5. Send the command:

```
cal.adjust.ac(11)          -- 100 uA, 1 KHz 3 A and LO front terminals.
```

AC current adjustment step 12: 1 mA at 1 kHz

To run ACI adjustment step 12:

1. On the calibrator, source **1 mA** at **1 kHz**.
2. Enable the **OPR** key.
3. Allow the calibrator and cable to settle properly.
4. Send the command:

```
cal.adjust.ac(12)          -- 1 mA, 1 KHz 3 A and LO front terminals.
```

AC current adjustment step 13: 10 mA at 1 kHz

To run ACI adjustment step 13:

1. On the calibrator, source **10 mA** at **1 kHz**.
2. Enable the **OPR** key.
3. Allow the calibrator and cable to settle properly.
4. Send the command:

```
cal.adjust.ac(13)          -- 10 mA, 1 KHz 3 A and LO front terminals.
```

AC current adjustment step 14: 100 mA at 1 kHz

To run ACI adjustment step 14:

1. On the calibrator, source **100 mA** at **1 kHz**.
2. Enable the **OPR** key.
3. Allow the calibrator and cable to settle properly.
4. Send the command:

```
cal.adjust.ac(14)          -- 100 mA, 1 KHz 3 A and LO front terminals.
```

AC current adjustment step 15: 1 A at 1 kHz

To run ACI adjustment step 15:

1. On the calibrator, source **1 A** at **1 kHz**.
2. Enable the **OPR** key.
3. Allow the calibrator and cable to settle properly.
4. Send the command:

```
cal.adjust.ac (15)         -- 1 A, 1 KHz, 3 A and LO front terminals.
```

AC current adjustment step 16: 2 A at 1 kHz

To run ACI adjustment step 16:

1. On the calibrator, source **2 A** at **1 kHz**.
2. Enable the **OPR** key.
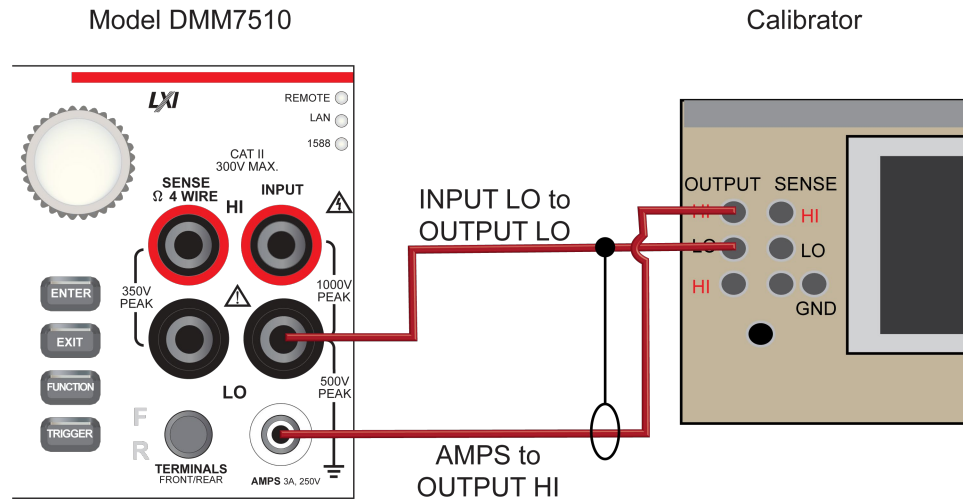3. Allow the calibrator and cable to settle properly.
4. Send the command:

```
cal.adjust.ac(16)          -- 2 A, 1 KHz 3 A and LO front terminals.
```

Prepare the Model DMM7510 for AC coupling adjustment step 17

To prepare for AC coupling adjustment step 17:

1. Connect a cable between the calibrator and the Model DMM7510 as shown in the figure below.

Figure 33: AC coupling verification connections
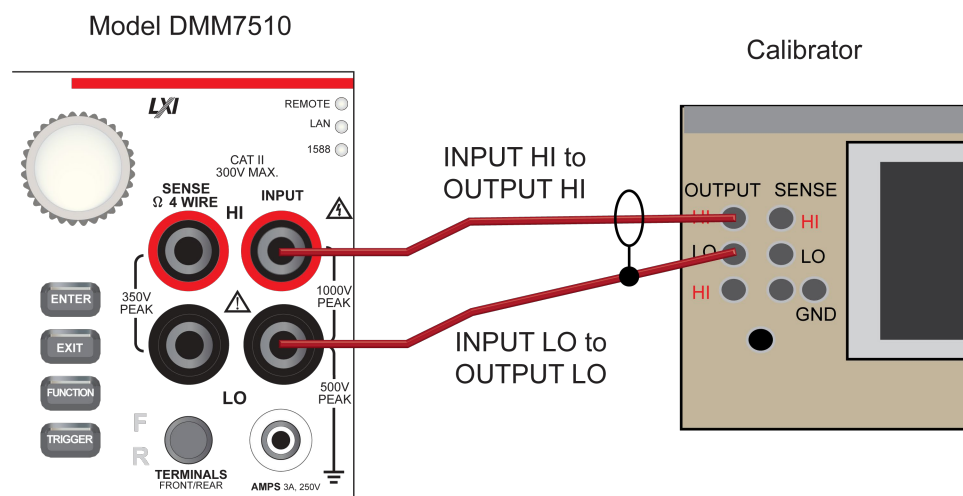
2. On the calibrator, source **1.0 V** at **10 Hz**.

3. Enable the **OPR** key.

4. Allow the instrument and cables to settle for 30 seconds.

AC coupling adjustment step 17

Send the command:

```
cal.adjust.ac(17, 1.0)   -- 1 V, 10 Hz HI and LO front terminals. Enter calibrator
    source value.
```

NOTE

For `cal.ac.adjust(17, <VAC1>)`, the source amplitude value must be entered. AC adjustment step 17 supports an allowed range of source values from 0.9 V$_{RMS}$ to 1.1 V$_{RMS}$.

Prepare the Model DMM7510 for AC frequency adjustment step 18

To prepare the Model DMM7510 for ACI adjustment step 8:

1. Connect the Keithley Instruments Model 3390 function generator to the Model DMM7510 INPUT HI and LO terminals as shown in the following figure.

Figure 34: Connections for frequency verification and adjustment
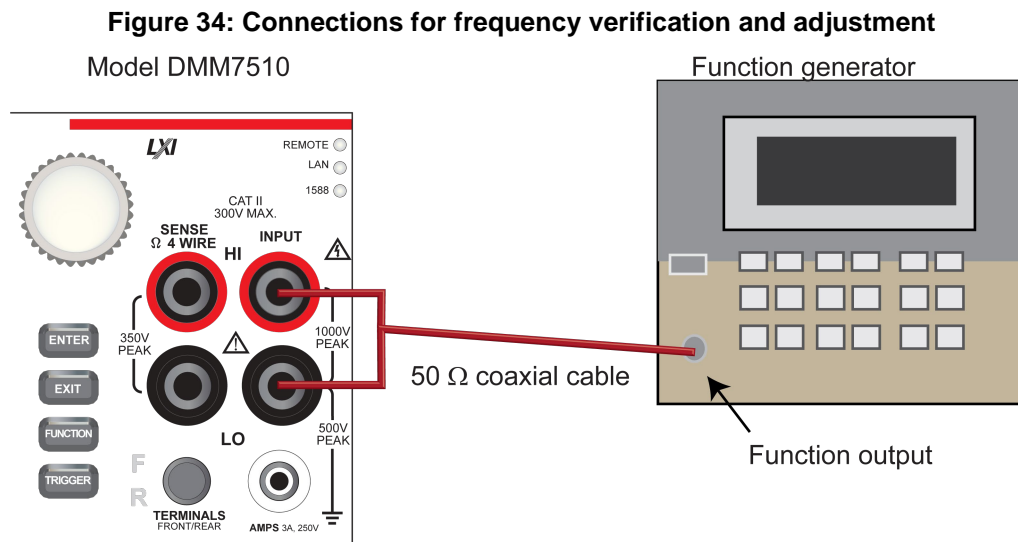
2. Set the function generator output impedance to **High**, amplitude of **5 V**$_{RMS}$, waveform to **square wave**.

3. Enable the output.

AC frequency adjustment step 18

Send the command:

```
cal.adjust.ac(18, 1000)    -- 1 V, 1 kHz HI and LO front terminals. Enter AFG
    frequency value.
```

NOTE

For `cal.ac.adjust(18, <F1k>)`, the source frequency value must be entered. AC adjustment step 18 supports an allowed range of source frequencies from 900 Hz to 1.1 kHz.

Save calibration and set the adjustment dates

Use the following commands to save and lock calibration adjustments.

```
cal.save()
cal.lock()
```

NOTE

Calibration is temporary until you send the `cal.save()` command. Also, calibration data is not saved if calibration is locked, if invalid data exists, or if all steps were not completed.

This completes the remote calibration adjustment procedure.

Setting time, adjustment, and verification dates

The Model DMM7510 calibration adjustment date variable is set automatically to the present system time when the `cal.save()` command is executed. However, you can also use Test Script Processor (TSP®) commands to set the time, verification date, and adjustment date.

To set the Model DMM7510 time, adjust date, and verify date using TSP commands:

```
-- Unlock calibration (if not already unlocked).
cal.unlock("KI000CAL")
-- Set the time (year, month, date, hour, minutes, seconds).
localnode.settime(2015, 1, 9, 10, 4, 38)
-- Set the adjustment and verification dates.
cal.adjust.date = os.time({year = 2015, month = 1, day = 9})
cal.verify.date = os.time({year = 2015, month = 1, day = 9})
```

NOTE

The `cal.verify.date` command is used to record the date of the last verification that was done independently of Model DMM7510 adjustment. Typically, this date is set at the completion of a performance verification procedure.

NOTE

Calibration must be unlocked to change the adjustment and verification dates, but changing these dates does not require using the `cal.save()` command and does not affect the `cal.count` command.

Adjustment command timing and error checking

Before each adjustment step, the input of the Model DMM7510 must be connected to an appropriate reference signal, as documented in Remote calibration adjustment procedures (on page 3-6).

NOTE

You must ensure that the correct signal is connected and fully settled before sending the associated `cal.adjust` command. Failing to wait for a signal to settle completely may result in a poor quality adjustment that could cause the Model DMM7510 to fail later performance verification.

Once the reference signal is stable, sending the calibration adjustment command initiates lengthy internal measurement operations in the Model DMM7510. These steps can take from a few seconds to up to 10 minutes to complete. Approximate times for each step are listed in the TSP command reference (on page 4-1) section of this manual.

After receiving a `cal.adjust command`, the Model DMM7510 display shows a calibration progress bar. It is important that you do not to disturb the test setup while the progress bar is showing. At the completion of a step, the progress bar is replaced by the message, "Calibration Step Complete."

Figure 35: Calibration progress window

If you are performing adjustment interactively, the display screen may provide sufficient feedback for you to proceed without sending any other Test Script Processor (TSP®) commands. Just observe the Model DMM7510 display and wait for the "Calibration Step Complete" message before setting up the next step and sending the next `cal.adjust` command.

Another method of getting calibration status feedback is to use the TSP prompts mode of operation. This is especially useful when you are entering `cal.adjust` commands interactively from an ethernet Telnet session.

To enable prompts mode, send the `localnode.prompts = 1` command. This causes the Model DMM7510 to return a `TSP>` prompt to the computer screen when it has completed a step and is ready for the next command. Prompts mode also returns a `TSP?` prompt if an event message is available (for example, if an error occurs during an adjustment step). See Handling events (on page 3-22) for more information.

Although not prohibited, prompts mode is not recommended for automated test programs. If prompts mode is enabled in an automated test, the control program must be constructed to expect and read each prompt that is sent after each TSP command is processed (including queries). Distinguishing prompt messages from normal query responses will cause unnecessary complications to the control program and should be avoided.

Adjustment step timing in automated programs

The simplest method of receiving programmatic notification of a completed calibration adjustment step is to place a `print()` statement following the `cal.adjust` command. The Test Script Processor (TSP®) command language allows multiple commands on a single command line, separated by spaces. For example:

```
cal.adjust.dc(0) print("Done with step 0")
```

This command performs adjustment step 0, and when the step is complete, places the `Done with step 0` string in the communications message queue. The control program should follow the command write with a read string operation, and when the string is received, continue to the next adjustment step. For example:

```
DMM7510.Write("cal.adjust.dc(0) print(""Done with step 0"")")
DMM7510.ReadString()
```

Because adjustment step 0 executes relatively quickly (in a few seconds), the back-to-back write-read operations will probably work in this example. However, for adjustment commands requiring more than a few seconds, the read operation will probably time out unless an appropriate communication timeout value for each step in the test program is provided. Setting programmatic timeout parameters varies from one test environment to another and is beyond the scope of this manual.

Using long timeouts is usually acceptable for a dedicated test system, but a several-minute timeout value may make a computer unresponsive during the timeout interval. One way of avoiding long timeout settings is to query the serial poll status byte that is available using `viReadSTB` in the VISA communication application programming interface (API), or by using direct GPIB communication methods.

Because bit value 16 of the status byte signals "Message Available" (MAV), a program can periodically poll the Model DMM7510 status and wait for the MAV bit to be set before reading the `Done with step...` message.

Handling events

If an error occurs while performing a calibration adjustment step, the Model DMM7510 displays an error message on the front panel. Typically, errors occur during calibration adjustment only if something is wrong with the test setup or reference signal (for example, if the calibrator output is not enabled before sending a `cal.adjust` command). After correcting the cause, the `cal.adjust` command that generated an error can be sent again without having to restart the entire calibration adjustment sequence.

Figure 36: Calibration error message
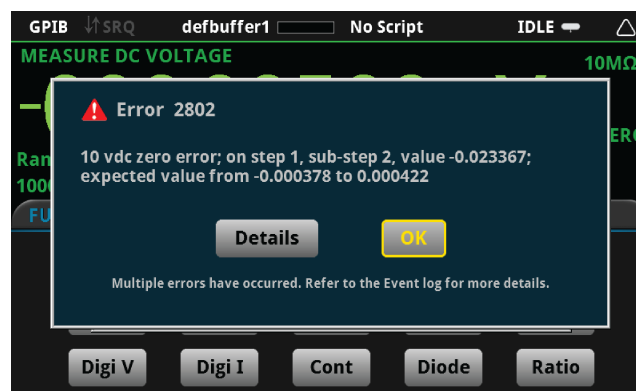
An automated test program can check for errors using the `eventlog.next()` function. Refer to the *Model DMM7510 Reference Manual* for details on `eventlog` commands. The same text that is displayed after a `cal.adjust` error is returned in the `eventlog.next()` message.

Example calibration adjustment code

This example is for Microsoft® Visual Studio® VB.net, using National Instruments VISA (NI-VISA™) Namespace MessageBasedSession to communicate with the Model DMM7510. This code only illustrates techniques for controlling adjustment command timing and checking for adjustment errors. It does not include any code for controlling a calibrator source (which is needed for most adjustment steps), and it contains no provisions to handle program exceptions such as communication timeout.

Only three front-input adjustment steps are shown. Steps `cal.adjust.dc(0)`, `cal.adjust.dc(1)`, and `cal.adjust.dc(2)` in this example require very different times to execute (approximately five seconds, three minutes, and seven minutes, respectively). All three steps may be performed with a 4-wire short connected to the front input, however only step `cal.adjust.dc(1)` requires the shorted input, and will generate errors if it is not in place.

```
Imports NationalInstruments.VisaNS
Module Module1
    Sub Main()
        Dim DMM7510 As MessageBasedSession
        DMM7510 = New MessageBasedSession("GPIB0::16::INSTR")
        ' Five seconds is a typical default communication timeout.
        DMM7510.Timeout = 5000
        ' Clear eventlog before starting adjustment.
        CheckForErrors(DMM7510)

        DMM7510.Write("cal.unlock(""KI000CAL"")")

        ' Normally, rear input adjustment steps are performed before front input
        ' steps. These steps are omitted in this example code.

        Console.WriteLine("Insert a four-wire short in DMM7510 front input")
        Console.WriteLine(" with F/R switch set to FRONT." & vbCrLf)
        Console.WriteLine("Wait five minutes, then press any key to continue...")
        Console.ReadKey()

        ' Use a simple query to control timing of adjustment step 0.
        Console.WriteLine("Starting adjust step 0")
        Console.WriteLine(DMM7510.Query("cal.adjust.dc(0) print(""Done with step
    0"")"))
        If CheckForErrors(DMM7510) Then GoTo CleanUp

        ' Increase the timeout value to handle a longer operation;
        ' set 3 1/2 minute communication timeout.
        DMM7510.Timeout = 210000
        Console.WriteLine("Starting adjust step 1")
        Console.WriteLine(DMM7510.Query("cal.adjust.dc(1) print(""Done with step
    1"")"))
        'Restore timeout to 5 seconds
        DMM7510.Timeout = 5000
        If CheckForErrors(DMM7510) Then GoTo CleanUp

        ' Example of Status Byte method to handle long operation without using
        ' long timeout value. NI VisaNS ReadStatusByte function maps to VISA
        ' specification viReadSTB function.

        ' Adjust step 2 requires 6-7 minutes.
```

```
            Console.WriteLine("Starting adjust step 2")
            DMM7510.Write("cal.adjust.dc(2) print(""Done with step 2"")")

            ' Check Message Available bit (16).
            ' Delay between status polling.
            ' Give feedback of something happening.
            Do Until (DMM7510.ReadStatusByte() And 16)
                System.Threading.Thread.Sleep(1000)
                Console.Write(".")
            Loop
            Console.WriteLine()
            ' Read "Done with step 2" message.
            Console.WriteLine(DMM7510.ReadString())
            If CheckForErrors(DMM7510) Then GoTo CleanUp

            ' Perform all remaining adjustment steps
            ' .
            ' .
            ' DMM7510.Write("cal.save()") ' cal.save() is required at completion of
            ' successful cal adjust, but do not save while experimenting with
            ' this example.
CleanUp:
            DMM7510.Write("cal.lock()")
            Console.WriteLine("press any key to exit...")
            Console.ReadKey()

    End Sub

Function CheckForErrors(DMM As MessageBasedSession) As Boolean
    ' This function returns TRUE if an error has occurred
    ' before calling the function.

            Dim Status As Boolean = False
            Dim eventnum As Integer
            Dim msg As String

            Do
                DMM.Write("eventnum, msg = eventlog.next(eventlog.SEV_ERROR)")
                eventnum = Convert.ToInt32(DMM.Query("print(eventnum)"))
                msg = DMM.Query("print(msg)")
                If eventnum Then
                    Console.WriteLine("Error {0} occurred.", eventnum)
                    Console.WriteLine(msg)
                    Status = True
                End If
            Loop While eventnum

            ' Clear messages from front panel too.
            DMM.Write("eventlog.clear()")
            Return Status

    End Function

End Module
```

TSP command reference

TSP commands

Introduction

This section contains detailed information on the Model DMM7510 remote calibration commands.

acal.count

This attribute returns the number of times autocalibration has been run.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Nonvolatile memory	Not applicable

Usage

value = acal.count	
value	The number of times autocalibration has been run

Details

The number of times that autocalibration has been run since the last factory calibration. The count restarts at 1 after a factory calibration.

Example

print(acal.count)	Returns the number of times autocalibration has been run. Example output: 15

Also see

Autocalibration (on page 2-4)
acal.run() (on page 4-6)

acal.lastrun.internaltemp

This attribute returns the internal temperature of the instrument when autocalibration was run.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Nonvolatile memory	Not applicable

Usage

```
temperature = acal.lastrun.internaltemp
```

temperature	The internal temperature

Details

The temperature is displayed in Celsius (°C).

The instrument updates the internal temperature value when the instrument refreshes autozero. If autozero is set to off or if autozero is not available for the selected function (such as capacitance, continuity, frequency or period), the internal temperature value is not updated.

Example

`print(acal.lastrun.internaltemp)`	Returns the internal temperature of the instrument when autocalibration was last run. Example output: `63.167084`

Also see

[acal.lastrun.tempdiff](#) (on page 4-3)
[acal.run()](#) (on page 4-6)

acal.lastrun.tempdiff

This attribute returns the difference between the internal temperature and the temperature when autocalibration was last run.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Not applicable	Not applicable

Usage

temperature = acal.lastrun.tempdiff	
temperature	The internal temperature

Details

The temperature is displayed in Celsius (°C).

The instrument updates the internal temperature value when the instrument refreshes autozero. If autozero is set to off or if autozero is not available for the selected function (such as capacitance, continuity, frequency or period), the internal temperature value is not updated.

Example

print(acal.lastrun.tempdiff)	Returns the difference between the temperature of the instrument when autocalibration was run and the present internal temperature. Example output: 4.5678

Also see

acal.lastrun.time

This attribute returns the date and time when autocalibration was last run.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Nonvolatile memory	Not applicable

Usage

```
dateTime = acal.lastrun.time
```

dateTime	The date and time

Details

The date and time is returned in the format:

`MM/DD/YYYY HH:MM:SS.NNNNNNNNN`

Where:

- `MM/DD/YYYY` is the month, date, and year
- `HH:MM:SS.NNNNNNNNN` is the hour, minute, second, and fractional second

Example

print(acal.lastrun.time)	Returns the date and time when the autocalibration was last run. Example output: `08/11/2014 16:30:26.745369595`

Also see

[acal.run()](#) (on page 4-6)
[Autocalibration](#) (on page 2-4)

acal.nextrun.time

This attribute returns the date and time when the next autocalibration is scheduled to be run.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Not applicable	Not applicable

Usage

```
dateTime = acal.nextrun.time
```

dateTime	The date and time when autocalibration is scheduled to be run

Details

The date and time is returned in the format:

`MM/DD/YYYY HH:MM:SS.NNNNNNNNN`

Where:

* `MM/DD/YYYY` is the month, date, and year
* `HH:MM:SS.NNNNNNNNN` is the hour, minute, second, and fractional second

Example

`print(acal.nextrun.time)`	Returns date and time when autocalibration is next scheduled to be run.
	Example output:
	`05/29/2014 17:11:17.000000000`

Also see

Autocalibration (on page 2-4)
acal.run() (on page 4-6)
acal.schedule() (on page 4-7)

acal.revert()

This function returns autocalibration constants to the previous constants.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

```
acal.revert()
```

Details

This command reverts the present set of autocalibration constants to the previous set of autocalibration constants.

The last run time and internal temperature are reverted to the previous values. The autocalibration count is not changed.

Example

acal.revert()	Auto calibration values are reverted to the previous set of autocalibration constants.

Also see

acal.run() (on page 4-6)

acal.run()

This function immediately runs autocalibration and stores the constants.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

```
acal.run()
```

Details

During autocalibration, a progress message is displayed on the front panel. At completion, an event message is generated.

If you have set up autocalibration to run at a scheduled interval, when you send the run command, the instrument adjusts the next scheduled autocalibration to be the next interval. For example, if autocalibration is scheduled to run every 7 days, but you run autocalibration on day 3, the next autocalibration will run 7 days after day 3.

When an autocalibration command is received, the instrument runs the autocalibration to completion before executing the next command.

Example

`acal.run()`	Autocalibration starts running. When it is complete, an information message is generated in the event log.

Also see

[acal.schedule()](#) (on page 4-7)
[Autocalibration](#) (on page 2-4)

acal.schedule()

This function sets how often autocalibration occurs or prompts you to run it.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes	Restore configuration	Nonvolatile memory Configuration script	Run every 8 hours starting at midnight

Usage

```
action, interval, hour = acal.schedule()
acal.schedule(acal.ACTION_NONE)
acal.schedule(action, interval)
acal.schedule(action, interval, hour)
```

action	Determines when and if the instrument automatically runs autocalibration: • To run autocalibration at the scheduled time: `acal.ACTION_RUN` • To notify you that the autocalibration needs to be run at the scheduled time: `acal.ACTION_NOTIFY` • To turn off scheduling: `acal.ACTION_NONE`; no other parameters are needed if none is selected
interval	Determines how often autocalibration should be run or notification should occur: • Every 8 hours: `acal.INTERVAL_8HR` • Every 16 hours: `acal.INTERVAL_16HR` • Every day: `acal.INTERVAL_1DAY` • Every 7 days: `acal.INTERVAL_7DAY` • Every 14 days: `acal.INTERVAL_14DAY` • Every 30 days: `acal.INTERVAL_30DAY` • Every 90 days: `acal.INTERVAL_90DAY`
hour	Specify when the autocalibration should occur; specify in 24-hour time format (`0` to `23`; default is `0`); not available for the 8-hour or 16-hour interval

Details

Autocalibration does not start until all actions that are active on the instrument are complete. When the scheduled time occurs, the autocalibration run command is placed in the command queue and will be executed after any previously sent commands or actions have executed. For example, if a trigger model is running when autocalibration is scheduled to run, autocalibration does not start until the trigger model stops.

If there is a command or action that is waiting a long time for an event, the autocalibration will not run until the event occurs, the action is aborted, or the instrument power is cycled.

If the scheduled time for autocalibration occurs before the warmup period completes, the instrument will not start autocalibration. The instrument waits until the warmup period is complete before starting a scheduled autocalibration. A message is displayed when warmup is complete and autocalibration is going to run.

If the instrument is powered off when an autocalibration was scheduled, autocalibration is run as soon as the warmup period is complete when the instrument is powered on.

You can run autocalibration manually even if a scheduled autocalibration is set.

When autocalibration is scheduled to run at a scheduled interval, but it runs at a time other than the scheduled interval, subsequent scheduled intervals are adjusted according to the actual autocalibration start time.

Example

```
acal.schedule(acal.ACTION_RUN, acal.INTERVAL_1DAY, 8)
```

Sets autocalibration to run every day at 8 am.

Also see

Autocalibration (on page 2-4)
acal.run() (on page 4-6)

cal.adjust.ac()

This function starts the specified AC adjustment step.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

```
cal.adjust.ac(step)
cal.adjust.ac(step, value)
```

step	The AC adjustment step to start
value	The value for this adjustment step (applies to steps 17 and 18)

Details

Descriptions (and approximate times to complete the step after sending the command):

- ACV adjustment (`cal.adjust.ac()`)
  - ACV step 1, 10 mV 1 kHz, ACV 100 mV range 10 percent of range (40 seconds)
  - ACV step 2, 100 mV 1 kHz, ACV 100 mV range full-scale and 1 V range zero (1 minute)
  - ACV step 3, 100 mV 50 kHz, ACV 100 mV frequency flatness adjustment (1 minute)
  - ACV step 4, 1 V 1 kHz, ACV 1 V range full-scale and 10 V range zero (1 minute)
  - ACV step 5, 1 V 50 kHz, ACV 1 V range frequency flatness adjustment (1 minute)
  - ACV step 6, 10 V 1 kHz, ACV 10 V range full-scale and 100 V range zero (1 minute)
  - ACV step 7, 10 V 50 kHz, ACV 10 V range frequency flatness adjustment (1 minute)
  - ACV step 8, 100 V 1 kHz, ACV 100 V range full-scale and 700 V range zero (1 minute)
  - ACV step 9, 100 V 50 kHz, ACV 100 V range frequency flatness adjustment (1 minute)
  - ACV step 10, 700 V 1 kHz, ACV 700 V range full-scale (1 minute)

- ACI adjustment (`cal.adjust.ac()`)
  - ACI step 11, 100 µA 1 kHz, ACI 1 mA range zero (45 seconds)
  - ACI step 12, 1 mA 1 kHz, ACI 1 mA range full-scale and 10 mA range zero (45 seconds)
  - ACI step 13, 10 mA 1 kHz, ACI 10 mA range full-scale and 100 mA range zero (45 seconds)
  - ACI step 14, 100 mA 1 kHz, ACI 100 mA range full-scale, 1 A and 3 A range zero (45 seconds)
  - ACI step 15, 1 A 1 kHz, ACI 1 A range full-scale (45 seconds)
  - ACI step 16, 2 A 1 kHz, ACI 3 A range full-scale (45 seconds)

- AC-coupling amplitude adjustment
  - ACV step 17, 1 V 10 Hz, ACV AC coupling amplitude adjustment (1 minute)

- Frequency adjustment (requires value parameter for frequency in Hertz)
  - ACV step 18, 1 V 1 kHz, squarewave, frequency adjustment (10 seconds)

For detail on how to use `cal.adjust.ac()`, refer to the steps under:

- Prepare the Model DMM7510 for ACV adjustment steps 1 to 10 (on page 3-14)
- Prepare the Model DMM7510 for ACI adjustment steps 11 to 16 (on page 3-17)
- Prepare the Model DMM7510 for AC coupling adjustment step 17 (on page 3-18)
- Prepare the Model DMM7510 for AC frequency adjustment step 18 (on page 3-19)

This command generates an error if:

- Calibration is locked
- The step is out of sequence
- The step does not complete successfully
- The value that is passed is invalid for the step, out of range, or not needed

Also see

cal.adjust.dc() (on page 4-12)
cal.lock() (on page 4-16)
cal.unlock() (on page 4-19)

cal.adjust.count

This attribute returns the number of times the instrument has been adjusted.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Nonvolatile memory	Not applicable

Usage

```
adjustments = cal.adjust.count
```

adjustments	The number of adjustments

Details

You can use this command if calibration is locked or unlocked.

The adjust count is read-only. The count is automatically incremented by one when the `cal.save()` command is sent with calibration unlocked.

Example

`Count = cal.adjust.count` `print(Count)`	Assign the number of times the instrument has been adjusted to a user variable named `Count`. Output the value. Example output: 3 This shows that the instrument has been adjusted 3 times.

Also see

cal.adjust.date (on page 4-11)

cal.adjust.date

This attribute contains the date when the instrument was last adjusted.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (RW)	Yes	Not applicable	Nonvolatile memory	Not applicable

Usage

```
adjustDate = cal.adjust.date
cal.adjust.date = (os.time{year = year, month = month, day = day})
cal.adjust.date = (os.time({year = year, month = month, day = day, hour = hour, min
    = minute, sec = second}))
```

adjustDate	The date when the last adjustment occurred
year	Year; must be more than 1970
month	Month (1 to 12)
day	Day (1 to 31)
hour	Hour in 24-hour time format (0 to 23)
minute	Minute (0 to 59)
second	Second (0 to 59)

Details

The date and time is returned in the format:

```
MMM DD YYYY HH:MM:SS.NNN
```

Where:

- `MMM DD YYYY` is the month, date, and year

- `HH:MM:SS.NNN` is the hour, minute, second, and fractional second

You can read this command if calibration is locked or unlocked. To set the date and time, calibration must be unlocked.

Example

`lastCal = cal.adjust.date` `print(lastCal)`	Assign the last adjustment date of the instrument to a user variable named `lastCal`. Output the value. Example output: `Sep 23 2014 10:07:51.447`

Also see

[cal.adjust.count](#) (on page 4-10)

cal.adjust.dc()

This function starts the specified DC adjustment step.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

```
cal.adjust.dc(step)
cal.adjust.dc(step, value)
```

step	The DC adjustment step to start
value	The value for this adjustment step (applies to steps 3, 4, and 5)

Details

Descriptions (and approximate times to complete the step after sending the command):

- DC step 0: Internal amplifier offset adjustment (10 seconds)
- DC step 1: 4-wire zero for DCI 1 A to 3 A, DCV, digitize DCV, 2W Ω, and 4W Ω (4 minutes)
- DC step 2: Open terminals (7 minutes):
  - DCI, zero 10 µA to 100 mA
  - DCV, 100 V and 1000 V full-scale
  - Resistance, 1 Ω to 1 GΩ full-scale
  - Digitize DCI and DCV full-scale
  - Waveform, analog trigger
  - Frequency, threshold level trigger
- DC step 3: 10 V, DCV 10 V range (50 seconds)
- DC step 4: -10 V, DCV 10 V range (50 seconds)
- DC step 5: 10 kΩ, resistance, 4W 10 kΩ range (50 seconds)

For detail on how to use `cal.adjust.dc()`, refer to DC voltage adjustment steps 0 to 5.

This command generates an error if:

- Calibration is locked
- The step is out of sequence
- The step does not complete successfully
- The value that is passed is invalid for the step, out of range, or not needed

Also see

cal.adjust.ac() (on page 4-9)
cal.lock() (on page 4-16)
cal.unlock() (on page 4-19)

cal.adjust.internaltemp

This attribute returns the internal temperature of the instrument when calibration was last adjusted.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Nonvolatile memory	Not applicable

Usage

`temperature = cal.adjust.internaltemp`	
`temperature`	The internal temperature in Celsius (°C)

Example

`print(cal.adjust.internaltemp)`	Returns the internal temperature of the instrument when calibration was last adjusted. Example output: `34.4`

Also see

cal.adjust.tempdiff (on page 4-15)

cal.adjust.rear.ac()

This function starts the specified rear AC adjustment step.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

`cal.adjust.rear.ac(step)` `cal.adjust.rear.ac(step, value)`	
`step`	The rear AC adjustment step to start
`value`	The value for this adjustment step (applies to step 2)

Details

Descriptions (and approximate times to complete the step after sending the command):

- AC current step 1, 0.5 A 1 kHz, AC current 10 A range zero (15 seconds)
- AC current step 2, 2 A to 10 A 1 kHz, AC current 10 A range full-scale (15 seconds)

For detail on how to use `cal.adjust.rear.ac()`, see Rear-terminal adjustment steps (on page 3-6). For code examples, refer to:

- Rear AC adjustment step 1: ACI 10 A zero adjustment (on page 3-9)
- Rear AC adjustment step 2: ACI 10 A full-scale adjustment (on page 3-9)

This command generates an error if:

- Calibration is locked
- The step is out of sequence
- The step does not complete successfully
- The value that is passed is invalid for the step, out of range, or not needed

Also see

cal.adjust.rear.dc() (on page 4-14)
cal.lock() (on page 4-16)
cal.unlock() (on page 4-19)

cal.adjust.rear.dc()

This function starts the specified rear DC adjustment step.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

```
cal.adjust.rear.dc(step)
cal.adjust.rear.dc(step, value)
```

step	The rear DC adjustment step to start
value	The value for this adjustment step (applies to step 3)

Details

Descriptions (and approximate times to complete the step after sending the command):

- DC step 0: Internal amplifier offset adjustment (10 seconds)
- DC step 1: 4-wire zero, DCI 10A, DCV, digitize DCV, 2W Ω, and 4W Ω (3 minutes)
- DC step 2: Open terminals, capacitance (25 seconds)
- DC step 3: 2 A, DCI 10 A range (15 seconds)

For detail on how to use `cal.adjust.rear.dc()`, see Rear-terminal adjustment steps (on page 3-6). For code examples, refer to:

- Rear DC adjustment step 0: Amplifier offset (on page 3-7)
- Rear DC adjustment step 1: 4-wire zero (on page 3-7)
- Rear DC adjustment step 2: Open circuit (on page 3-8)
- Rear DC adjustment step 3: DCI 10 A full-scale adjustment (on page 3-8)

This command generates an error if:

- Calibration is locked
- The step is out of sequence
- The step does not complete successfully
- The value that is passed is invalid for the step, out of range, or not needed

Also see

cal.adjust.rear.ac() (on page 4-13)
cal.lock() (on page 4-16)
cal.unlock() (on page 4-19)

cal.adjust.tempdiff

This attribute returns the difference between the internal temperature and the temperature when adjustment was last done.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (R)	Yes	Not applicable	Not applicable	Not applicable

Usage

```
temperature = cal.adjust.tempdiff
```

`temperature`	The difference in temperature

Details

The temperature is displayed in Celsius (°C).

The instrument updates the internal temperature value when the instrument refreshes autozero. If autozero is set to off or if autozero is not available for the selected function (such as capacitance, continuity, frequency or period), the internal temperature value is not updated.

Example

`print(cal.adjust.tempdiff)`	Returns the difference between the temperature of the instrument when calibration was adjusted and the present internal temperature. Example output: `4.5678`

Also see

cal.adjust.internaltemp (on page 4-13)

cal.lock()

This function prevents access to instrument calibration.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

```
cal.lock()
```

Details

Calibration data is locked during normal operation. To perform calibration, you must unlock calibration.

This command does not save calibration data.

> ⚠ CAUTION
>
> Calibration data is lost if it is you do not save it before sending `cal.lock()`. Use `cal.save()` to save the data.

An error is generated if this command is issued when calibration is already locked.

Example

```
cal.unlock("KI000CAL")
-- Perform operations to generate the calibration data
cal.save()
cal.lock()
```

Unlock the calibration for the instrument using the default password.
Save the calibration data.
Lock the calibration data.

Also see

cal.save() (on page 4-18)
cal.unlock() (on page 4-19)

cal.password

This attribute sets the password that you send when you unlock calibration.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (W)	Yes	Not applicable	Nonvolatile memory	KI000CAL

Usage

```
cal.password = password
```

password	A string that represents the password to unlock calibration; must be 10 characters or less

Details

This command can only be sent when calibration is unlocked.

The password is not saved until calibration is saved with `cal.save()`.

NOTE

Be sure to record the password; there is no command to retrieve the password once it is set.

Example

`cal.unlock("KI000CAL")`
`cal.password = "XYZCorp"`
`cal.lock()`
`cal.unlock("XYZCorp")`
	To change the default calibration password, unlock the calibration with the default password.
	Sets the password to `XYZCorp`.
	Lock calibration. Use the password `XYZCorp` for subsequent unlocks.

Also see

cal.save()

This function saves the calibration constants.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	Yes			

Usage

```
cal.save()
```

Details

This command stores the internally calculated calibration constants that were derived during the comprehensive calibration procedure. It also sets the adjustment date and increments the adjustment count. Calibration constants are retained indefinitely once saved.

Calibration is temporary unless the changes are saved. Calibration data is not saved if:

- Calibration is locked.

- Invalid data exists (for example, if a calibration step failed or was aborted).

- An incomplete number of calibration steps were done (for example, omission of a negative full-scale step).

Example

```
cal.unlock("KI000CAL")
-- Perform operations to generate the calibration data
cal.save()
cal.lock()
```

Unlock the calibration for the instrument using the default password.
Save the calibration data.
Lock the calibration data.

Also see

cal.adjust.count (on page 4-10)
cal.adjust.date (on page 4-11)
cal.lock() (on page 4-16)
cal.unlock() (on page 4-19)

cal.unlock()

This attribute unlocks calibration operations.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Function	No			

Usage

```
cal.unlock(password)
```

password	A string containing the password to unlock calibration

Details

Calibration data is locked during normal operation. To perform calibration, you must unlock calibration.

The default password is `KI000CAL`. You can use `cal.password` to change the default.

An error is generated if this command is issued when calibration is already unlocked.

Example

```
cal.unlock("KI000CAL")
-- Perform operations to generate the calibration data
cal.save()
cal.lock()
```

Unlock the calibration for the instrument using the default password.
Save the calibration data.
Lock the calibration data.

Also see

cal.lock() (on page 4-16)
cal.password (on page 4-17)

cal.verify.date

This attribute contains the date of the last calibration verification.

Type	TSP-Link accessible	Affected by	Where saved	Default value
Attribute (RW)	Yes	Not applicable	Nonvolatile memory	Not applicable

Usage

```
verifyDate = cal.verify.date
cal.verify.date = os.time({year = year, month = month, day = day})
cal.verify.date = os.time({year = year, month = month, day = day, hour = hour, min
    = minute, sec = second})
```

verifyDate	The date when the last verification occurred
year	Year; must be more than 1970
month	Month (1 to 12)
day	Day (1 to 31)
hour	Hour in 24-hour time format (0 to 23)
minute	Minute (0 to 59)
second	Second (0 to 59)

Details

The date and time is returned in the format:

```
MMM DD YYYY HH:MM:SS.NNN
```

Where:

- `MMM DD YYYY` is the month, date, and year
- `HH:MM:SS.NNN` is the hour, minute, second, and fractional second

You can read this command if calibration is locked or unlocked. To set the date and time, calibration must be unlocked.

When using the `os.time()` function, if no parameters are specified, the current date and time of the instrument is used.

The verification date is also available from the front panel:

1. Press the **MENU** key.
2. Select **Calibration**.
3. The verification date is displayed as the **Calibration Date**.

Example 1

```
cal.verify.date = os.time({year=2014, month=9, day=5})
print(cal.verify.date)
```
Set the verify calibration date to September 5, 2014.
Verify the date. Example output:
```
Sep 5 2014 12:00:00.000
```

Example 2

```
cal.verify.date = os.time()
```
Set the calibration verification to the present date of the instrument.

Also see

[cal.adjust.date](#) (on page 4-11)

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