Section 6

Measuring 4-wire resistance with offset compensation

In this section:

Introduction

This application example demonstrates how to use the Model DMM7510 to accurately measure a resistance device.

To provide the best resistance measurement accuracy, the four-wire (Kelvin) measurement and the offset compensation methods are used for this test. Offset compensation is a measuring technique that reduces or eliminates thermoelectric EMFs in low-level resistance measurements. The voltage offsets because of the presence of thermoelectric EMFs (V_{EMF}) can adversely affect resistance measurement accuracy.

To overcome these offset voltages, you can use offset-compensated ohms.

Equipment required

- One Model DMM7510
- Four insulated banana cables, such as the Model 1756 Standard Test Lead Kit that is provided with the Model DMM7510 (you will need another set)
- One device to be tested; the application shown here uses a 20 Ω resistor (actual resistance value can vary with availability and user discretion)
- One computer set up for communication with the Model DMM7510

Device connections

You can use either the front-panel or the rear-panel terminals for this application. The following figures show the physical connections for the front and rear panels. Note that you must use either the front terminals or the rear terminals — you cannot mix front and rear connections.

The front-panel and rear-panel connections are both safety banana jacks.

To use the 4-wire connection method:

1. Connect one set of test leads to the INPUT HI and INPUT LO terminals.
2. Connect the other set of test leads to the SENSE HI and SENSE LO terminals.
3. Connect the INPUT HI and SENSE HI connections to one of the device-under-test (DUT) leads. Connect the sense connection as close to the DUT as possible.
4. Connect the INPUT LO and SENSE LO to the other DUT lead. Connect the sense connection as close to the DUT as possible.

⚠ WARNING

To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test leads.

There is no internal connection between protective earth (safety ground) and the LO terminals of the Model DMM7510. Therefore, hazardous voltages (more than 30 V_{rms}) can appear on LO terminals. This can occur when the instrument is operating in any mode. To prevent hazardous voltage from appearing on the LO terminals, connect the LO terminal to protective earth if your application allows it. You can connect the LO terminal to the chassis ground terminal on the front panel or the chassis ground screw terminal on the rear panel. Note that the front-panel terminals are isolated from the rear-panel terminals. Therefore, if you are using the front-panel terminals, ground to the front-panel LO terminal. If using the rear-panel terminals, ground to the rear panel LO terminal.

Figure 25: Front-panel connections for 4-wire resistance measurements

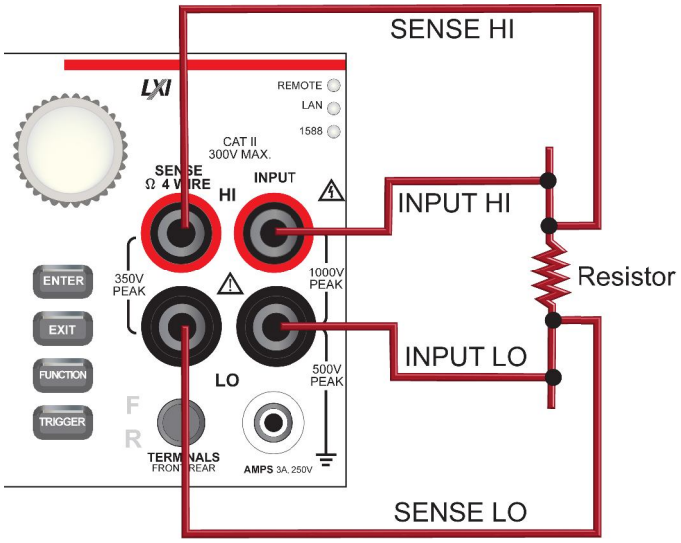
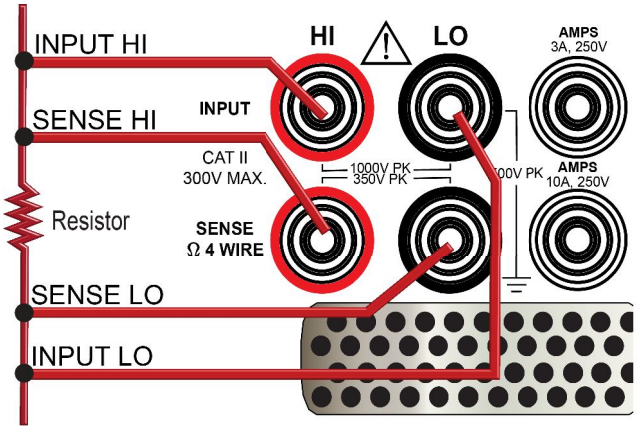


Figure 26: Rear-panel connections for 4-wire resistance measurements



4-wire resistance measurements with offset compensation

This application demonstrates how to use the Model DMM7510 to measure the resistance of a device or component. You can make this measurement from the Model DMM7510 front panel or over the remote interface using SCPI code or TSP code. For information about setting up remote communications, see Remote communications interfaces (on page 3-1).

For this application, you will:

- Reset the instrument.
- Select the 4-wire resistance function. This method eliminates the effect of the lead resistance on measurement accuracy.
- Enable offset compensation.
- Make measurements from the front panel or the remote interface.

Using the front panel

To set up the application from the front panel:

1. Press the **POWER** button on the front panel to turn on the instrument.
2. On the FUNCTIONS swipe screen, select **4WΩ** to select the 4-wire resistance measure function.
3. Press the **MENU** key.
4. Under Measure, select **Settings**.
5. Set Offset Compensation to **On**.
6. Press the **HOME** key.

The measurement readings are displayed in the top area of the Home screen.

Using SCPI commands

This sequence of SCPI commands measures the resistance of a device or component. The device under test is connected to the Model DMM7510 and controlled remotely.

You may need to make changes so that this code will run in your programming environment.

Send the following commands for this example application:

Command	Description

`*RST`
`:SENS:FUNC "FRES"`
`:SENS:FRES:OCOM ON`
`:SENS:FRES:AZER ON`
`:SENS:FRES:NPLC 1`
`:READ?`
	• Reset the Model DMM7510
	• Set to measure four-wire resistance
	• Enable offset compensation
	• Enable auto zero
	• Set NPLC to 1
	• Read the resistance value

Using TSP commands

NOTE

The following TSP code is designed to be run from Keithley Instruments Test Script Builder (TSB). TSB is a software tool that is available from the Keithley Instruments website. You can install and use TSB to write code and develop scripts for TSP-enabled instruments. Information about how to use TSB is in the online help for TSB and in the "Introduction to TSP operation" section of the *Model DMM7510 Reference Manual*.

To use other programming environments, you may need to make changes to the example TSP code.

By default, the Model DMM7510 is configured to use the SCPI command set. You must select the TSP command set before sending TSP commands to the instrument.

To enable TSP commands:

1. Press the **MENU** key.
2. Under System, select **Settings**.
3. For Command Set, select **TSP**.
4. At the prompt to reboot, select **Yes**.

In this example, the Model DMM7510 makes one resistance reading. After the code is executed, the data is displayed in the Instrument Console of Test Script Builder.

Send the following commands for this example application:

```
--Reset the Model DMM7510 to the default settings
reset()
--Set the measure function to 4-wire resistance
dmm.measure.func = dmm.FUNC_4W_RESISTANCE
--Enable autozero (set to dmm.OFF to disable)
dmm.measure.autozero.enable = dmm.ON
--Enable offset compensation (set to dmm.OFF to disable)
dmm.measure.offsetcompensation.enable = dmm.ON
--Set the number of power line cycles to 1
dmm.measure.nplc = 1
--Read the resistance value
print(dmm.measure.read())
```

Test results

The results of a low-resistance measurement test using a 20 Ω resistor are shown in the table below.

For example, if the resistor specification a tolerance of ±0.1 % and a temperature coefficient of ±15 ppm/°C, a compliant resistor measures between 19.97 Ω and 20.03 Ω.

Offset compensation	Resistance
OFF	0.020035852875 kΩ
ON	0.019991329184 kΩ