Section 7

Scanning resistors using 4W measurement

In this section:

Introduction

This example application demonstrates how to use the DAQ6510 to accurately measure resistance across multiple devices. To obtain the best results, the 4-wire (Kelvin) measurement method and offset compensation are used for this test.

Typical resistance measurements made using the 2-wire method source current through the test leads and the device under test (DUT). The voltage is measured, and the resistance is calculated.

It is difficult to obtain accurate 2-wire resistance measurements when the DUT is lower than 100 Ω. Typical lead resistances lie in the range of 1 mΩ to 10 mΩ. When the 2-wire method is applied to low-resistance measurements, there is a small but significant voltage drop across the resistance of each test lead. The voltage measured by the instrument is not the same as the voltage directly across the DUT.

The 4-wire method is preferred for low-resistance measurements. With this configuration, the test current is sourced through the DUT using one set of test leads, while a second set of SENSE leads measures the voltage across the DUT. The voltage-sensing leads are connected as close to the device under test as possible to avoid including the resistance of the test leads in the measurement.

Thermoelectric voltages (EMFs) can seriously affect low-resistance measurement accuracy. The DAQ6510 can apply the offset-compensated ohms method (OCOMP), which makes one normal resistance measurement and one using the lowest current source setting to eliminate EMFs.

For this example, you will use resistors of different low values across multiple channels of a 7700 multiplexer module and examine how the 4-wire measurement method provides a more accurate reading than the 2-wire method. Fixed measurement ranges are applied in order to optimize scanning speed and OCOMP is applied to correct for any EMF effects.

NOTE

For comprehensive information on 4W resistance measurements, thermoelectric EMFs, and offset compensation methods, see the "Low Level Measurements Handbook," which is available on the Keithley Instruments website (tek.com/keithley).

Equipment required

- One DAQ6510
- One Model 7700 20-channel differential multiplexer module
- One computer setup for communication with the instrument
- Six resistors of 100 Ω, 68 Ω, 10 Ω, 2.2 Ω, 0.5 Ω, and 0.2 Ω
- One device or component to be tested

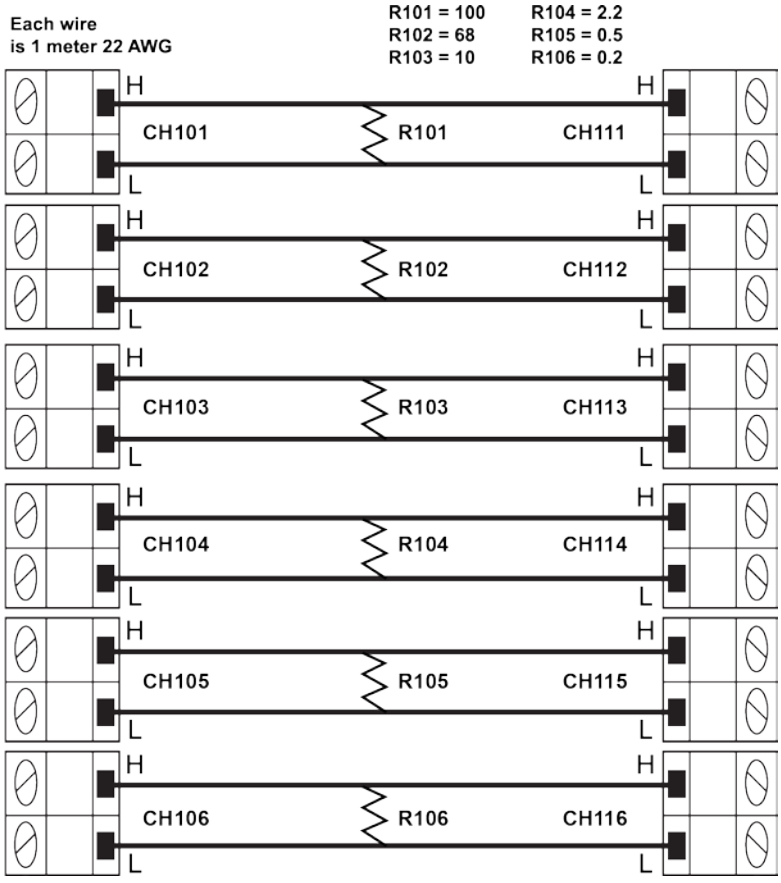
Device connections

This example application uses the DAQ6510 to perform a 4-wire measurement using multiple channels on a 7700 multiplexer module.

For this example you will:

- Configure channels 101, 102, 103, 104, 105, and 106 to measure resistors (in this case, 100 Ω, 68 Ω, 10 Ω, 2.2 Ω, 0.5 Ω, and 0.2 Ω).
- Pair channels 111 to 116 with channels 101 to 106, respectively, to provide the SENSE connections needed for 4-wire measurement.
- Select fixed ranges and apply offset compensation to each channel.
- Execute 100 scans for all selected channels.

Figure 38: Schematic of 4W measurement



NOTE

To highlight the impact of test lead resistance on low-resistance measurements, and how the correction methods improve readings, the connections to each DUT consist of one meter of 22 AWG wire.

⚠ WARNING

To prevent electric shock, test connections must be configured such that the user cannot come in contact with 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 .

There is no internal connection between protective earth (safety ground) and the LO terminals of the DAQ6510. 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 (safety ground) 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. Failure to follow these guidelines can result in injury, death, or instrument damage.

Scanning resistors using 4-wire measurements

Using the front panel

To setup the application from the front panel:

1. Press the **POWER** switch on the front panel to turn on the instrument.
2. Set the **TERMINALS** switch to REAR.
3. Press the **MENU** key**.**
4. Under Channel, select **Scan**.
5. Select the **+** button to add groups of channels (101 to 106) and select **OK**.
6. Select **4W Resistance** on the Measure Functions screen.
7. Select **Offset Compensation,** select **On.**
8. In the upper left corner of the screen, select the Menu icon to reveal options, select **Expand Group.** The left side of the pane allows you to modify the range on each channel.
9. Select channel 101 by selecting **4-Wire Res**.
10. Under the Settings tab, select Range and set to **100 W.**
11. Select chanel 102 by selecting **4-Wire Res** and set the Range to **100 W.**
12. Select chanel 103 by selecting **4-Wire Res** and set the Range to **10 W.**
13. Select chanel 104 by selecting **4-Wire Res** and set the Range to **10 W.**
14. Select chanel 105 by selecting **4-Wire Res** and set the Range to **1 W.**
15. Select chanel 106 by selecting **4-Wire Res** and set the Range to **1 W**.
16. Locate the Scan tab, and set the Scan Count to **100**.
17. Select the **Start** button at the bottom of the left-side pane to start the scan.

You can monitor active readings during the scan or review all scanned data after the scan finishes.

To watch active readings during scan:

1. Press the **HOME** key.
2. Select the button to the right of **Watch Channel**.
3. Select the channels of interest and select **OK** to accept.

To review all the data after the scan finishes:

1. Press the **MENU** key.
2. Under the Views column, choose **Reading Table**.

Using SCPI commands

This sequence of SCPI commands executes a 4-wire resistance scan.

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

Send the following commands for this example application:

Commands	Descriptions
`*RST`	• Reset the DAQ6510
`ROUT:SCAN:COUN:SCAN scanCnt`	• Set the number of times the scan is repeated
`FUNC 'FRES',(@101:106)`	• Set function to 4-wire measurement
`FRES:OCOM ON, (@101:106)`	• Set offset compensation to "on"
`FRES:RANG 100, (@101,102)`	• Set the fixed range at 100 Ω
`FRES:RANG 10, (@103,104)`	• Set the fixed range at 10 Ω
`FRES:RANG 1, (@105,106)`	• Set the fixed range at 1 Ω
`ROUT:SCAN:CRE (@101:106)`	• Set the scan list
`TRAC:CLE`	• Clear the reading buffer
`INIT`	• Initiate the scan
`*WAI`	• Wait for scan completion

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 webpage on the Tektronix website (tek.com/keithley). 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 *DAQ6510 Reference Manual*.

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

By default, the DAQ6510 uses 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**.

This sequence of TSP commands initiates a series of temperature measurements. After the code executes, the data is displayed in the Instrument Console of Test Script Builder.

After the scan, the data in the buffer is stored on a USB flash drive.

Send the following commands for this example application:

```
-- Reset the instrument to the default settings
reset()
scanCount = 100
-- set up each channels function, range and offset compensation
channel.setdmm("101, 102", dmm.ATTR_MEAS_FUNCTION, dmm.FUNC_4W_RESISTANCE,
   dmm.ATTR_MEAS_RANGE, 100, dmm.ATTR_MEAS_OFFCOMP_ENABLE, dmm.OCOMP_ON)
channel.setdmm("103, 104", dmm.ATTR_MEAS_FUNCTION, dmm.FUNC_4W_RESISTANCE,
   dmm.ATTR_MEAS_RANGE, 10, dmm.ATTR_MEAS_OFFCOMP_ENABLE, dmm.OCOMP_ON)
channel.setdmm("105, 106", dmm.ATTR_MEAS_FUNCTION, dmm.FUNC_4W_RESISTANCE,
   dmm.ATTR_MEAS_RANGE, 1, dmm.ATTR_MEAS_OFFCOMP_ENABLE, dmm.OCOMP_ON)
-- set up Scan
scan.add("101,102,103,104,105,106")
scan.scancount = 100
-- set up trigger model
trigger.model.initiate()
-- wait till scan completes
waitcomplete()
```

Test results

The table below compares the values of scanned DUTs using 4-wire and 2-wire measurement methods with the six resistors listed in the Instrument and Device Connection section.

NOTE

The data provided in each cell of the table is the average of 100 scans.

Nominal value (Ω)	Four-wire measurement with offset compensation (Ω)	Four-wire measurement with NO offset compensation (Ω)	Two-wire measurement (Ω)
100	98.3242	98.3206	98.5831
68	67.9920	68.0080	67.2703
10	10.00998	10.00141	10.28680
2.2	2.20413	2.20588	2.51011
0.5	0.555823	0.559395	0.84131
0.2	0.221831	0.221796	0.53091