Section 5

Measuring DC voltage with high accuracy

In this section:

Introduction

This example application demonstrates how to use a DMM6500 to make high-accuracy DC voltage measurements.

This type of test is often done in metrology laboratories where high accuracy is required for calibration and verification.

Equipment required

- One DMM6500
- One computer setup for communication with the instrument
- Two insulated banana cables (you can use the Model 1757 Standard Test Lead Kit that is provided with the DMM6500, or equivalent)
- One device or component to be tested

Device connections

This example uses the DMM6500 to measure DC voltage using either the front or rear input terminals. Both the front and rear-panel connections are safety banana jacks.

NOTE

You must use either the front or the rear terminals. You cannot mix the front and rear connections.

Make sure that the front-panel **TERMINALS** switch is set to the terminals you are using. An illuminated green LED next to the switch indicates that the instrument is reading the front-panel terminals. An illuminated yellow LED indicates that the instrument is reading the rear-panel terminals.

Connecting devices to the instrument:

1. Connect the test leads to the INPUT HI and LO terminals.
2. Connect the INPUT HI and INPUT LO to the leads.

Figure 30: Front-panel connections

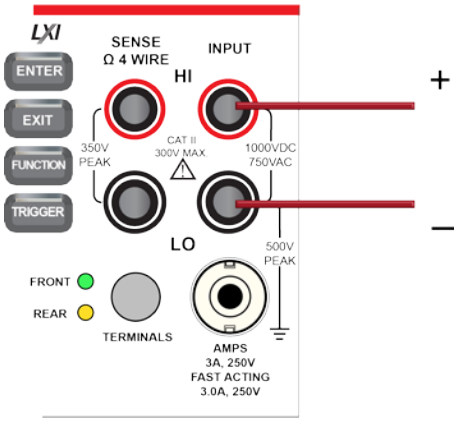
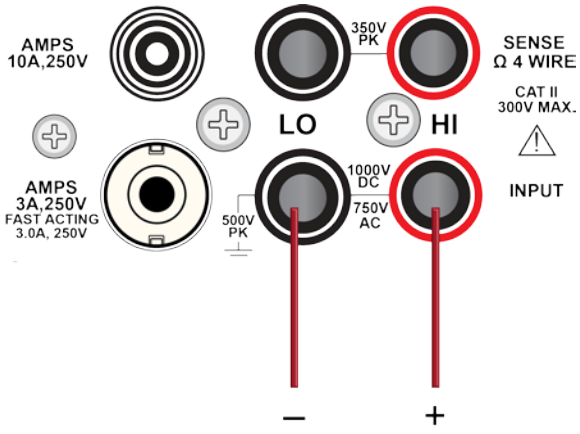


Figure 31: Rear-panel connections



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 DMM6500. 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.

Measuring DCV with high accuracy

This application demonstrates how to use the DMM6500 to make high-accuracy DC voltage measurements. You can make the measurements from the front-panel interface 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:

- Restart the instrument.
- Select the DC voltage function.
- Set the integration rate to 10 power line cycles (PLCs) at 60 Hz line frequency; 10 PLCs provide an aperture of 166.7 ms.
- Set the input impedance to Auto.
- Turn on autozero. This allows the instrument to optimize the accuracy of readings by checking reference measurements.
- Enable a repeating filter with a count of 100. This reduces noise error because the results are more stable when the measurements are averaged.
- Generate readings from the front panel or the remote interface.

Using the front panel

Restart the instrument and select the function, integration rate, autozero, and filter settings:

1. Press the **POWER** switch on the front panel to turn on the instrument.
2. Select the **REAR** terminals**.**
3. On the FUNCTIONS swipe screen, select **DCV**.
4. On the top half of the Home screen, select **Range**.
5. Select **10 V**.
6. Swipe to the **SETTINGS** screen.
7. Set the Rate to **10**.
8. Select **OK**.
9. Set Input Z to **Auto**.
10. Verify that **Auto Zero** is selected.
11. Press the **MENU** key.
12. Under Measure, select **Calculations**.
13. Set Filter to **On**.
14. Select **Settings,** (the small gear next to Filter)
15. Set the Type to **Repeat**.
16. Set the Count to **100**.
17. Select **OK**.
18. Press the **HOME** key.

NOTE

If measurements are not updating, press the TRIGGER key for a few seconds. Verify that the trigger mode is set to Continuous Measurement.

The measurement is displayed in the top area of the Home screen.

With a repeating filter count of 100 and NPLC of 10, the measurement cycle time is slow but accurate. By reducing the values of these settings, you can get faster but less accurate readings. The balance between speed and accuracy depends on the needs of your specific application.

Using SCPI commands

This sequence of SCPI commands makes a single high-accuracy DC voltage measurement.

You may need to make changes so that this code will run in your programming environment. In the table, the SCPI commands have a light gray background.

Send the following commands for this example application:

Commands	Descriptions
`*RST`	• Reset the DMM6500
`:SENS:FUNC "VOLT:DC"`	• Set the instrument to measure DC Voltage
`:SENS:VOLT:RANG 10`	• Set the measure range to 10 V
`:SENS:VOLT:INP AUTO`	• Set the input impedance to auto so the instrument selects 10 G_ for the 10 V range
`:SENS:VOLT:NPLC 10`	• Set the integration rate (NPLCs) to 10
`:SENS:VOLT:AZER ON`	• Enable autozero
`:SENS:VOLT:AVER:TCON REP`	• Set the averaging filter type to repeating
`:SENS:VOLT:AVER:COUN 100`	• Set the filter count to 100
`:SENS:VOLT:AVER ON`	• Enable the filter
`:READ?`	• Read the voltage value; it is a few seconds before the reading is returned

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. 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 *DMM6500 Reference Manual*.

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

By default, the DMM6500 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 makes a single high accuracy DC voltage measurement. After the code executes, the data is displayed in the Instrument Console of Test Script Builder.

Send the following commands for this example application:

```
--Reset the instrument to the default settings.
reset()
--Set the measure function to DC voltage.
dmm.measure.func = dmm.FUNC_DC_VOLTAGE
--Set the measurement range to 10 V.
dmm.measure.range = 10
--Set the number of power line cycles to 10.
dmm.measure.nplc = 10
--Set the input impedance to auto so it selects 10 Gohm for the 10V range.
dmm.measure.inputimpedance = dmm.IMPEDANCE_AUTO
--Enable autozero.
dmm.measure.autozero.enable = dmm.ON
--Set the averaging filter type to repeating.
dmm.measure.filter.type = dmm.FILTER_REPEAT_AVG
--Set filter count to 100.
dmm.measure.filter.count = 100
--Enable the filter.
dmm.measure.filter.enable = dmm.ON
--Read the voltage value.
print(dmm.measure.read())
```

Test results

The following table shows the tradeoff between accuracy and measurement speed of based on the integration rate (NPLC), averaging filter, and autozero settings. The first row of data is measured using the setup documented in this example. The other rows show the results as the integration rate, filter, and autozero settings are changed.

DC voltage	Measurement time (seconds)	Integration rate (NPLC)	Filter	Auto zero
4.9999858103	33.542816	10	On	On
4.9999824274	0.335426	10	Off	On
4.9999791921	0.035426	1	Off	On
4.9999907688	0.017023	1	Off	Off

Figure 32: DC voltage high accuracy test results