WHITE PAPER



Measuring Low Current Consumption with a Digital Multimeter

KEYSIGHT

Introduction

DMMs measure current. It is one of the essential functions of a digital multimeter (DMM). These instruments are the go-to tool for most engineers and technicians when they need to make current or voltage measurements. New generation DMMs have expanded current ranges that will give you better measurement resolution, allowing you to make more accurate low-current measurements.

DMM Current Readings

Many 6½ digit DMMs are limited to a 1 mA low current range when measuring DC. A 1 mA current range offers a best-case resolution of 1 nA. Other DMMs offer a 100-µA or 200-µA range, which in turn gives 100-pA resolution.

The new generation DMMs offer extended current ranges. The new current ranges include 10 µA, 1 µA on the low end, and a 10-A range on the higher end; Table 1.

When measuring very small currents be sure to null your readings before making the measurement. Doing so removes any system related offsets, which ensures an accurate measurement.

Greater measurement insight at low current resolution

The 34465A and 34470A Truevolt Series, part of Advanced grade of Keysight DM Digital Multimeters, feature a low current range of 1 µA, which in turn offers an exceptional 1-pA resolution. With pA resolution on the 1-µA range, the potential current measurements range from 1 pA to 10 A, resulting in 13 orders of magnitude to be measured by these DMMs.

Accuracy specifications: DC current and other DC functions

Specification ± (% of reading + % of range)

Table 1. New current ranges available with the 34465A and 34470A Truevolt Series of DMMs

Range / frequency	24 hours TCAL ±1 °C	90 days TCAL ±5 °C	1 year TCAL ±5 °C	2 years TCAL ±5 °C	Temperature coefficient / °C
DC current					
1 µA	0.007 + 0.005	0.030 + 0.005	0.050 + 0.005	0.060 + 0.005	0.020 + 0.010
10 µA	0.007 + 0.002	0.030 + 0.002	0.050 + 0.002	0.060 + 0.002	0.015 + 0.006
100 µA	0.007 + 0.001	0.030 + 0.001	0.050 + 0.001	0.060 + 0.001	0.015 + 0.004
1 mA	0.007 + 0.003	0.030 + 0.005	0.050 + 0.005	0.060 + 0.005	0.015 + 0.005
10 mA	0.007 + 0.020	0.030 + 0.020	0.050 + 0.020	0.060 + 0.020	0.020 + 0.020
100 mA	0.010 + 0.004	0.030 + 0.005	0.050 + 0.005	0.060 + 0.005	0.020 + 0.005
1 A	0.050 + 0.006	0.070 + 0.010	0.080 + 0.010	0.100 + 0.010	0.050 + 0.010
3 A	0.180 + 0.0020	0.200 + 0.020	0.200 + 0.020	0.230 + 0.020	0.050 + 0.020
10 A	0.050 + 0.0010	0.120 + 0.010	0.120 + 0.010	0.150 + 0.010	0.050 + 0.010

Burden Voltage

When measuring low levels of current, burden voltage can be a concern. Burden voltage is the change in potential created when current flows through the shunt resistor of a DMM. While this is not usually a concern, very sensitive components must be aware of the voltage, especially if the DMM is placed in series in the return path as shown in Figure 1. By adding a small voltage above the low of the power supply, the low of your device might well be above your design tolerance.

Consider moving the DMM in series to the positive side of your power supply. If you can increase the voltage to accommodate for the burden voltage, you can still supply the correct voltage to your device and measure current.

If the burden voltage gets sufficiently large, the offset voltage on the return path might cause a problem; depending on your device. Table 2 shows the typical burden voltages of DMMs.

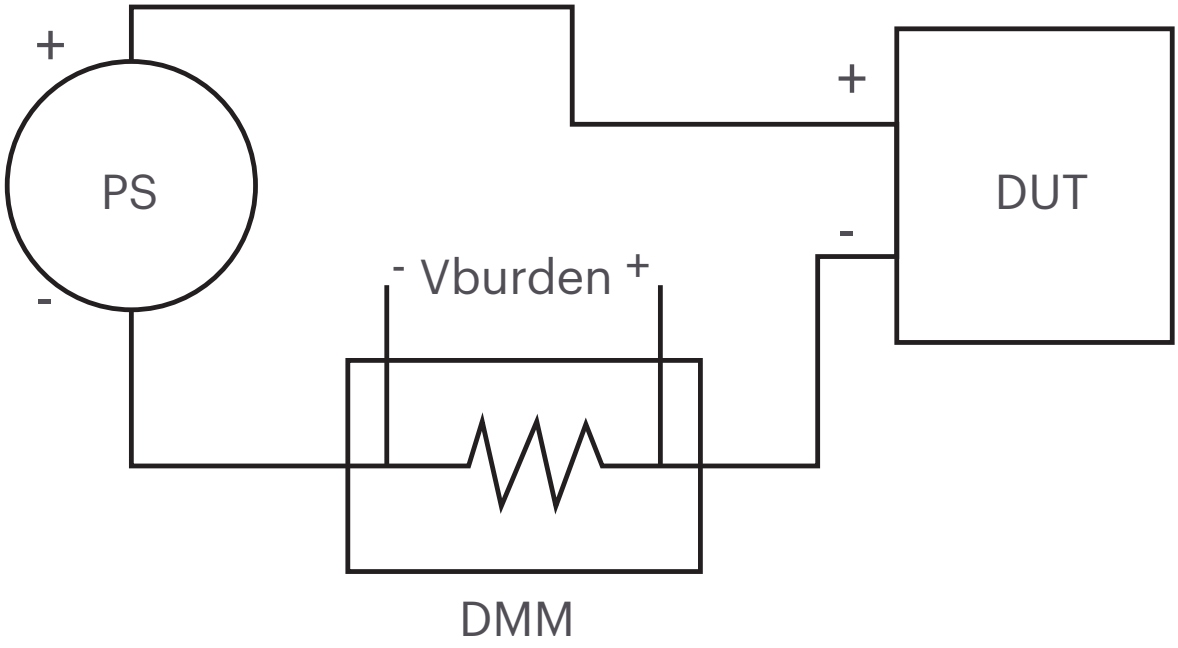


Figure 1. Shown here is the DMM in series on the return path

DC and AC current burden voltage at full scale

Table 2. This table represents the burden voltages of the different current ranges of the 34465A and 34470A

DC current range	Burden voltage
1 µA	< 0.0011 V
10 µA	< 0.011 V
100 µA	< 0.11 V
1 mA	< 0.11 V
10 mA	< 0.027 V
100 mA	< 0.27 V
1 A	< 0.7 V / 0.05 V [1]
3 A	< 2.0 V / 0.15 V [1]
10 A	< 0.5 V

1. The second burden voltage can be obtained by using the 10 A range input.



Dynamic current measurements

Dynamic current measurements are quite complex due to the DMM range change based on the level of current you are measuring. There are specialized instruments such as source and measure unit (SMU) that can digitize power, voltage, and current without ranging issues. While this may be an excellent solution for current characterization, the solution is a bit more expensive than using a DMM. In situations where budget or flexibility is a concern, there is a DMM solution that allows you to accomplish many of the same measurements.

Whether you measure the reverse and forward bias current of an LED or the sleep/operating mode current of a battery powered device, you will have a very large difference between the two modes of operation.

Figure 2 illustrates a simple block diagram for battery drain analysis. You can effectively monitor the power drain from your battery powered device using one DMM to monitor the voltage and another DMM to monitor the current. On the DMMs, the 10-A input is separate from the low current input. This setup uses the low current input.

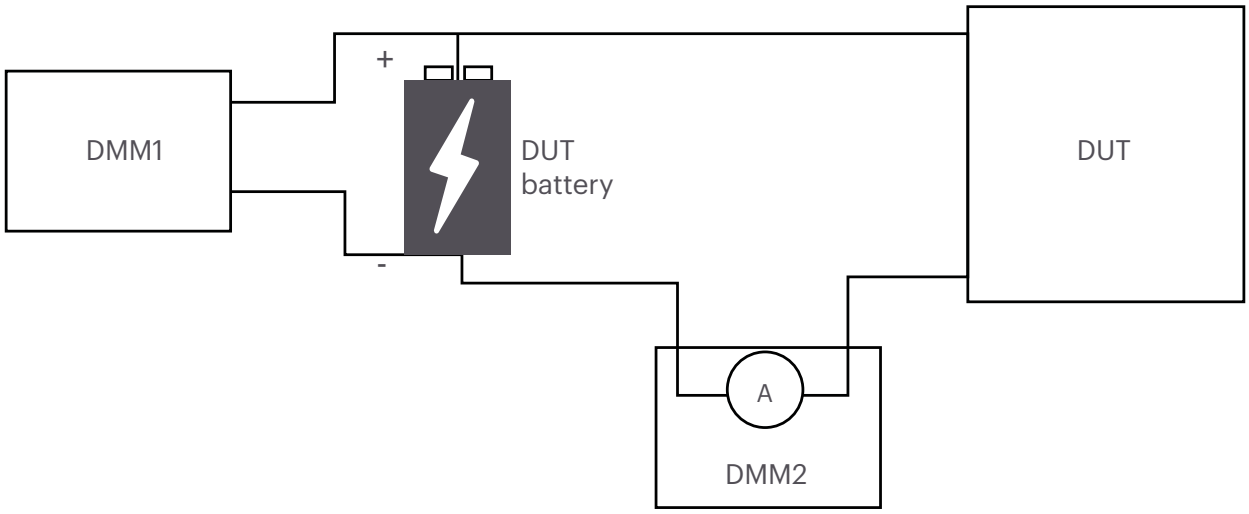


Figure 2. This block diagram depicts a battery drain analysis using two DMMs

Figure 3 shows a typical current profile of a portable radio transceiver. As you can see, the current draw is complex due to a wide range of sleep, standby, and active modes. The dynamic range of the current is broad because the operating currents are drawing approximately 30 to 40 mA, while the standby currents are only 1 to 10 μA.

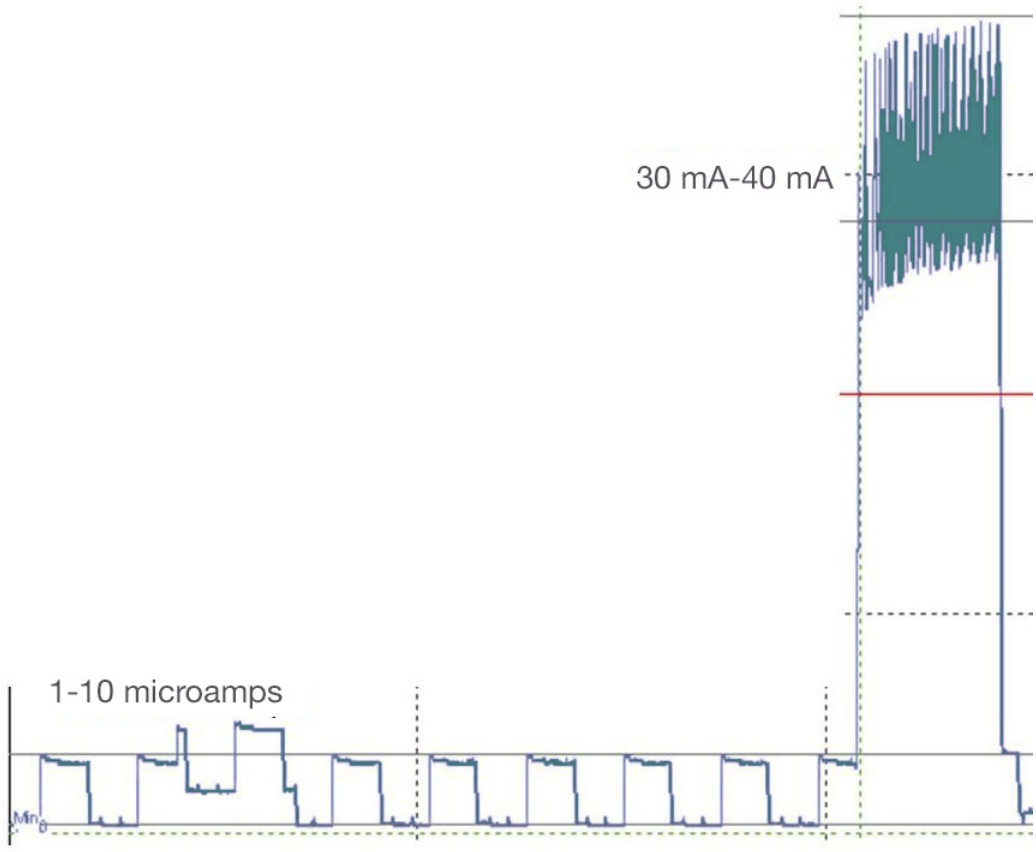


Figure 3. Shown here is a current profile from a portable radio

Measurement Tip

Using Keysight's True*volt* DMM digitizing capability and High Speed (HS) option, you can measure fast changing characteristics while measuring with a time resolution with a time resolution of 20 μs. To effectively digitize with accurate timing, ensure that auto zero and auto ranging is turned off. This eliminates the timing variation that occurs when the DMM makes additional readings for the auto zero or switching to a different range.

To get accurate readings for both ranges with a DMM, you need to take multiple reading sweeps with different ranges. One method for capturing the current profile would be to run the device-under-test (DUT) multiple times to capture the sleep and standby modes separately and then the operating mode currents.

In the first capture, set the DMM to the 100-mA range and 0.001 PLC (20 μs per sample). This setting will capture the complete current signal, including the active mode values between 30 to 40 mA, but provides less resolution on the lower current measurements.

Figure 4 shows a trend chart view of the currents read using a DMM. Notice that the lower current measurements seem to be very uniform, which is due to a loss of resolution. To measure the low current values, you need to take another measurement at a lower current range. Once you have captured the readings, the data can be saved to memory and analyzed on a PC.

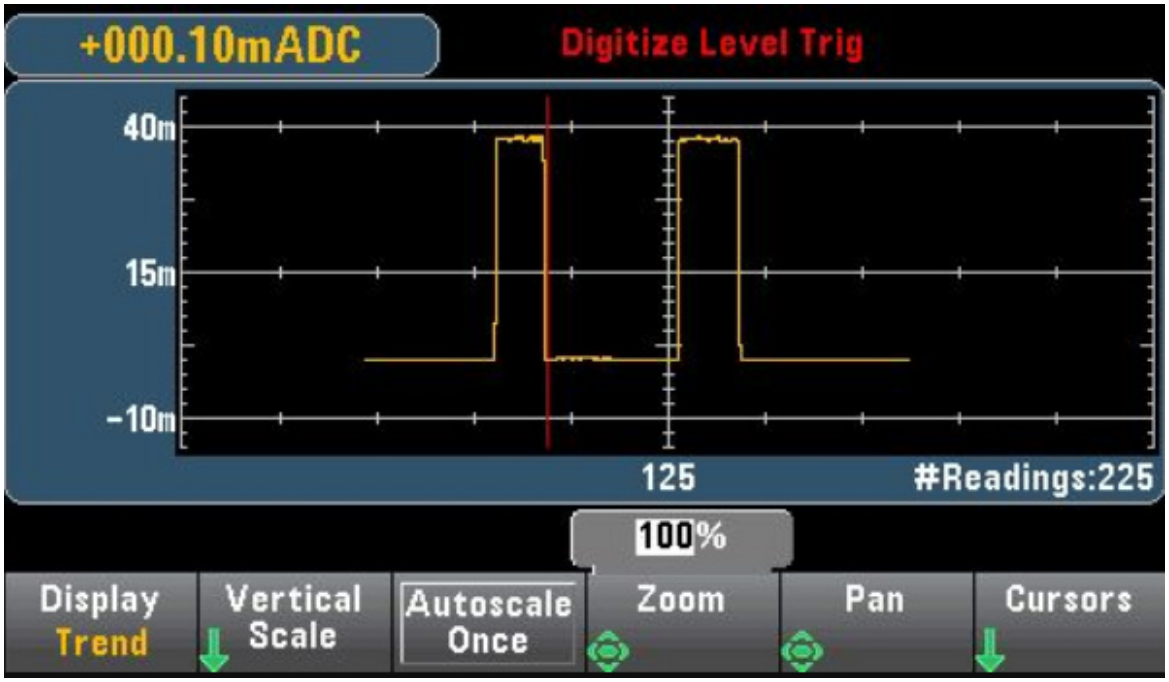


Figure 4. Captured operating current with the 34465A DMM

Next, you can set the DMM to a lower current range for the standby and sleep currents. Figure 5 shows a graphical data capture, using BenchVue, of the standby currents measured by the top graph. The bottom graph shows the DCV readings.



Figure 5. These two graphs illustrate the digitized DCI (top image) and DCV (bottom image) consumption

You can use Keysight's BenchVue software to control and trigger both DMMs simultaneously. Use the digitizing mode of the DMM to ensure 20 µs/sample timing. Note that the data logging mode in BenchVue includes PC overhead that can interfere when precise timing is required.

Figure 6 shows the statistics and actual readings from the data set. The currents captured range from approximately 2 to 10 µA. They were captured with the DUT in standby mode, thus allowing for a single range current capture. Anything above 120 percent of the range will result in an overload condition.



Figure 6. Shown here are the statistics and actual readings from the data set captured in Figure 5

Conclusion

With extended current ranges and digitizing capabilities, the Keysight's 34465A and 34470A True*volt* DMMs can effectively characterize dynamic currents. Whether your DUT is drawing high current at 10 A or you need to measure lower current in the pico-amp region, the True*volt* DMMs have the features and measurement capabilities to be an important instrument on your bench.

For more information about the Keysight True*volt* Digital Multimeters, go to https://www.keysight.com/us/en/products/digital-multimeters-dmm.html

To learn more about Keysight's BenchVue DMM software application, please go to https://www.keysight.com/us/en/product/BV0001B/pathwave-benchvue-digital-multimeter-app.html

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