Keysight Technologies
Measuring Low Current Consumption with a Digital Multimeter

Application Brief

Test Challenges:

- Characterizing the power consumption of a battery powered device
- Testing the current draw of a low leakage diode

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Overview

DMMs measure current. It's one of the basic 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. Keysight has added additional current ranges to the True*volt* DMM series that allow you to measure a wider range of currents than other 6.5 digit DMMs. Learn some of the details on how expanded current ranges can help your measurements.

Characterizing the power consumption of a battery powered device

You are tasked with characterizing the power consumption of a battery powered device. Designers have optimized the device's current draw, but need complete measurements of the current from sleep mode to full operating load. To fully characterize the device's different current cycles, you decide to use a 34465A DMM. Its' 1-µA DC current range provides the pico-amp resolution needed to accurately characterize the sleep mode. It also has a high range, 10 A, which allows you to measure a wide range of currents for your battery powered device when operating in full load conditions.

Testing the current draw of a low leakage diode

You are testing the current draw of a low leakage diode. To do so, you need pico-amp resolution, but with the ability to measure forward currents with dozens of mA's. While you can perform these measurements with a more expensive electrometer, you might also be able to make them using a stable DC power supply and a new True*volt* DMM. The 34465A/34470A True*volt* DMMs feature a low DC current range of 1 µA, which allows for pico-amp resolution with less than 100 pA accuracy (1 year specs, depending on current reading) to accurately characterize leakage current. With a no-open circuit range change up to 3 A, you can characterize your device's backward and forward current without breaking the circuit.

DMM current readings

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

The new 34465A and 34470A True*volt* Series of DMMs feature a low current range of 1 µA, which in turn offers an exceptional 1-pA resolution. The new True*volt* DMMs also offer extended current ranges that are simply not available with other DMMs in this class. The new current ranges include 10 µA, 1 µA on the low end, and a 10-A range on the higher end (Figure 1). 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.

Measurement tip

When measuring very small currents be sure to null your readings before your crucial measurement. Doing so removes any system related offsets, allowing the measurement to be more accurate.

Accuracy specifications: DC current and other DC functions
Specification ± (% of reading + % of range)

Range/frequency	24 hours T_{CAL} ± 1 °C	90 days T_{CAL} ± 5 °C	1 year T_{CAL} ± 5 °C	2 years T_{CAL} ± 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

Figure 1. Shown here are all of the new current ranges available with the 34465A and 34470A True*volt* Series of DMMs.
Please refer to the True*volt* Series DMM data sheet, publication number 5991-1983EN, for additional specification details.

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 normally 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 2. By adding a small voltage above the low of the power supply, the low of your device might well be above your design tolerance.

If the burden voltage gets sufficiently large, the offset voltage on the return path might cause a problem; depending on your device. The burden voltages of the 34465A and 34470A DMMs are shown in Figure 3.

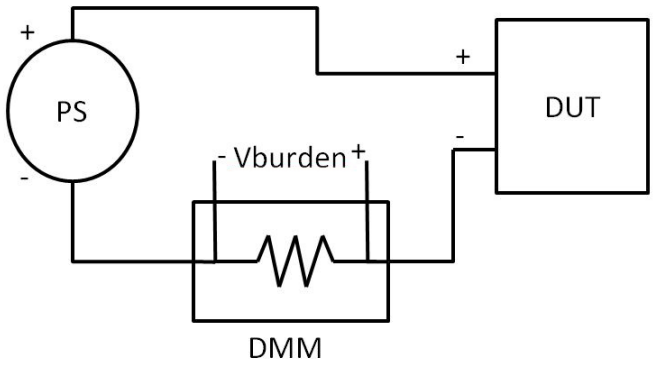

Figure 2. Shown here is the DMM in series on the return path.

Measurement tip

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.

DC and AC current burden voltage at full scale

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.

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

Dynamic current measurements

Dynamic current measurements can be quite complex due to the DMM range change based on the level of current you are measuring. Keysight offers specialized instruments (e.g., the Keysight N6782A SMU) that can digitize power, voltage and current without ranging issues. While this may be a great solution for current characterization, the solution is a bit more expensive than using a True*volt* DMM. In situations where budget or flexibility is a concern, the True*volt* DMM allows you to accomplish many of the same measurements.

Whether you are measuring 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 4 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 True*volt* DMMs, the 10-A input is separate from the low current input. This setup uses the low current input.

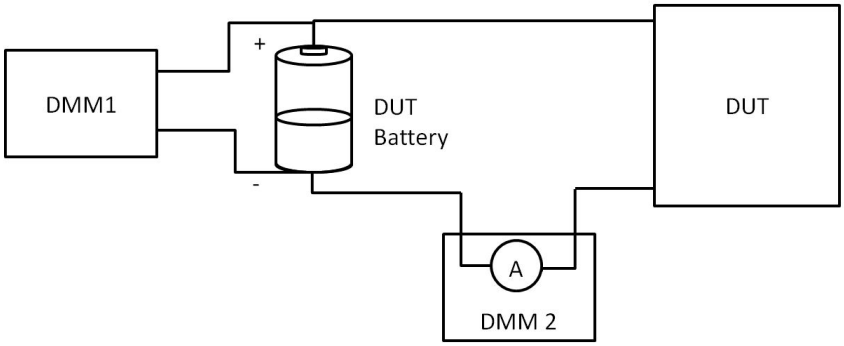

Figure 4. This block diagram depicts a battery drain analysis using two DMMs.

Measurement tip

Using the 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.

Figure 5 shows a typical current profile of a portable radio transceiver. As you can see, the current draw is complicated with a wide range of sleep, standby and active modes. The dynamic range of the current is large because the operating currents are drawing approximately 30 to 40 mA, while the standby currents are only 1 to 10 µA.

In order 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 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.

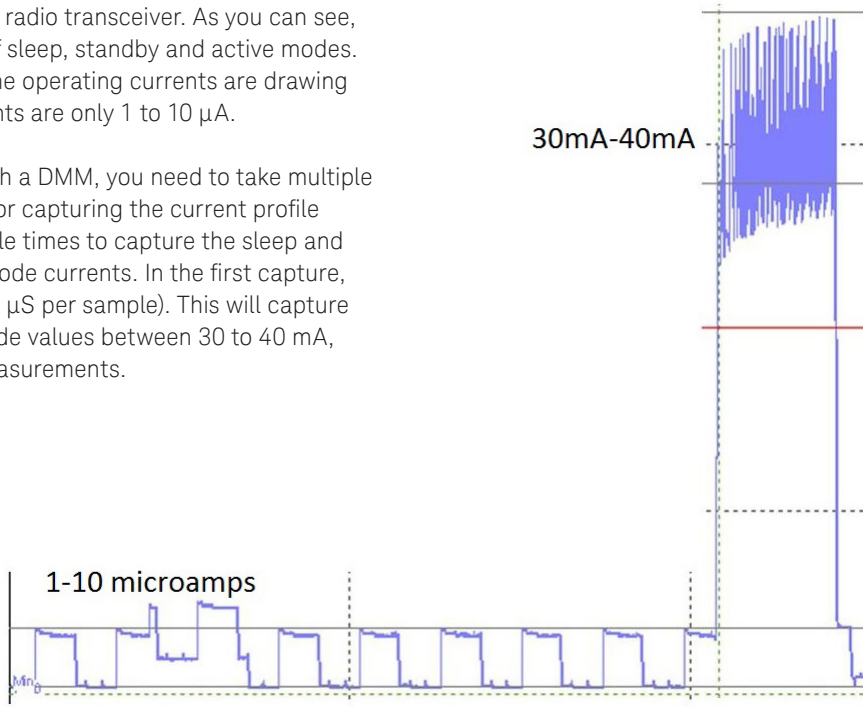

Figure 5. Shown here is a current profile from a portable radio.

Figure 6 shows a trend chart view of the currents read using a 34465A DMM. Notice that the lower current measurements seem to be very uniform, which is due 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.

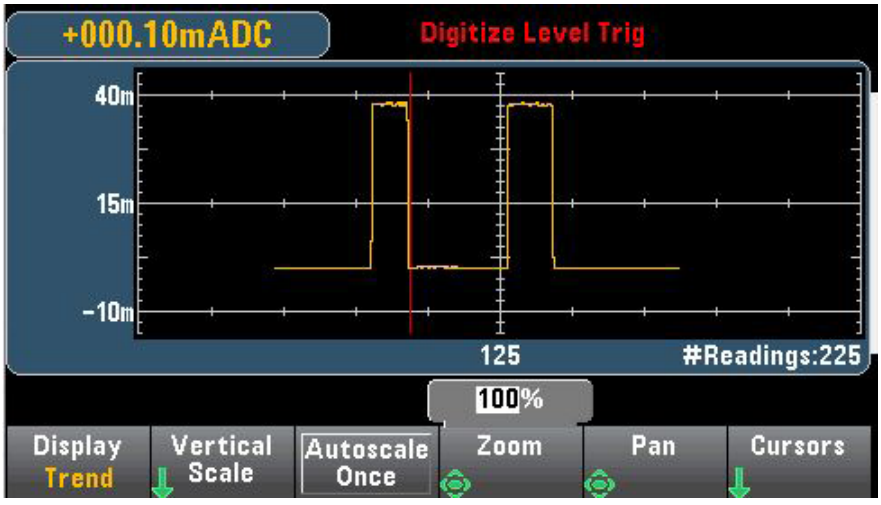

Figure 6. This operating current was captured with the 34465A DMM. Shown here is the DMM front panel.

Measurement tip

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 datalogging mode in BenchVue includes PC overhead that can interfere when precise timing is required.

Next, you can set the DMM to a lower current range for the standby and/or sleep currents. Figure 7 shows a graphical data capture, using BenchVue, of the standby currents measured by the top graph. The bottom graph shows the DCV readings. Figure 8 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 7. These two graphs illustrate the digitized DCI (top image) and DCV (bottom image) consumption.

Figure 8. Shown here are the statistics and actual readings from the data set captured in Figure 7.

Summary

With extended current ranges and digitizing capabilities, the 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 new True*volt* DMMs have the features and measurement capabilities to be a workhorse instrument on your bench.

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