10 Things You Must Know Before Buying Your Next Benchtop Digital Multimeter

eBook

KEYSIGHT

INTRODUCTION

The digital multimeter (DMM) is the most commonly used instrument on an engineer's bench. We use it almost every day. Whether we are making a quick voltage measurement or data logging temperature over a long period, our DMM just has to work.

Most of us have a one-sided relationship with our DMMs. In exchange for all the work they do, we expect very little maintenance and upkeep in return. Despite their importance, DMMs rarely get the attention they deserve. From concept to prototype turn-on and debugging all the way through testing and validation, the DMM is present at every stage of the product life cycle, ensuring accuracy from start to finish.

This eBook takes a closer look at the DMM and all that it does. We explore 10 things you should know about DMMs. The topics covered are applicable whether you are considering your next DMM purchase or want more from the DMM currently on your bench.

Contents

CHAPTER 1

Bench vs. Handheld

Bench vs. Handheld

This eBook focuses on bench DMMs. While we will not discuss handheld DMMs, keep in mind that many of the concepts we cover for bench DMMs also apply to handheld DMMs. In general, bench DMMs have higher accuracy, better resolution, enhanced system programmability, and four-wire measurement functionality compared to a handheld DMM. Handheld DMMs tend to provide lower accuracy and offer simpler functionalities. They also tend to be more portable and are typically used in a standalone fashion. Many technicians and electricians use handheld DMMs because of their portability, while many engineers and designers prefer bench DMMs for their accuracy and broad measurement capabilities.

Some handheld DMMs offer *Bluetooth*® connectivity and mobile applications. In contrast, bench DMMs typically offer wired connectivity options such as LAN, USB, or GPIB, enabling automated testing, seamless integration into test racks, and the use of PC software or custom programs for precise control. If automated testing and remote programming are critical, a bench DMM is the better choice. In addition, since bench DMMs are less portable and harder for colleagues to "borrow," they tend to stay on your bench longer. Throughout the rest of this eBook, the term DMM refers to bench DMMs.

CHAPTER 2

Digits, Accuracy, Resolution

Digits, Accuracy, Resolution

To understand digits, accuracy, and resolution, we begin by asking the most common DMM question: What is the half digit? The number of digits is the first specification you will notice about a DMM. If you have a 3.5-digit DMM, the half digit is the most significant (indicated in red in the Table 1).

Whole digits have a range of values from zero to nine. However, the half digit can be only a zero or a one. In Table 1, you can see that a 3.5-digit DMM offers plus or minus 2,000 counts. A 4.5-digit DMM offers plus or minus 20,000 counts, and so on. The number of digits directly translates to the number of counts, which is the level of detail that is measurable. This is known as the resolution.

Table 1. Relationship Between DMM Display Digits, Counts, and Resolution

Display digits	Measurement range	Resolution count
3.5 digits	± 1,999	2,000
4.5 digits	± 19,999	20,000
5.5 digits	± 199,999	200,000
6.5 digits	± 1,999,999	2,000,000

Figure 1. Keysight benchtop digital multimeter displaying 6.5 digits of resolution

Digits and counts, however, are not directly related to accuracy. This is a common misconception. Figure 2 demonstrates how accuracy relates to resolution on a measurement scale. Accuracy represents how good the measured valued is, or how much you can trust it. Resolution is the level of detail that is measurable. Accuracy and resolution are the key specifications to consider when choosing a DMM.

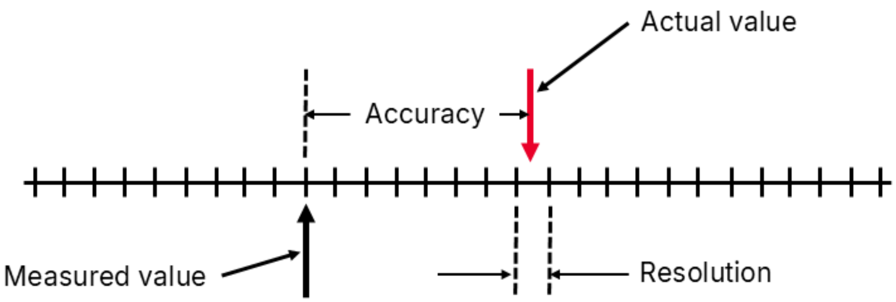


Figure 2. Accuracy versus resolution in a DMM

CHAPTER 3

Visualization

Visualization

One of the key considerations when selecting a DMM is how it presents measurement data. How do you want to see your results? Most DMMs provide a default numerical display, which works well for basic readings. However, advanced models offer additional visualization tools — such as trend charts (value versus time) and histograms — that reveal measurement behavior at a glance. Some even stream digitized values directly over the I/O port for external analysis.

On a crowded bench, a DMM that stands out with clear, easy-to-read visuals can make a big difference in workflow efficiency. Keysight DMMs, for example, include advanced graphical capabilities with built-in trend and histogram charts that provide immediate insight into measurement stability, variation, and distribution. These tools make it easier to spot patterns, track performance over time, and identify anomalies without the need for external software.

The 4.3- or 7-inch high-resolution color graphical displays found on these models enhance visibility and make both real-time monitoring and statistical analysis more intuitive. Whether you are tracking drift in a long-duration test or quickly verifying signal consistency, these integrated display features help streamline troubleshooting and improve productivity.

Figure 3. Smart Bench Essentials Plus DMM with a large 7-inch dual display

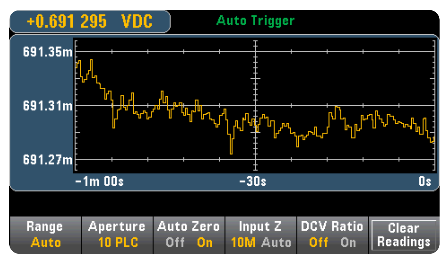


Figure 4. Trend chart display

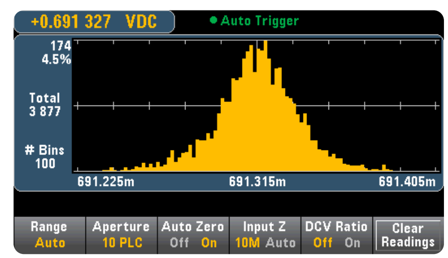
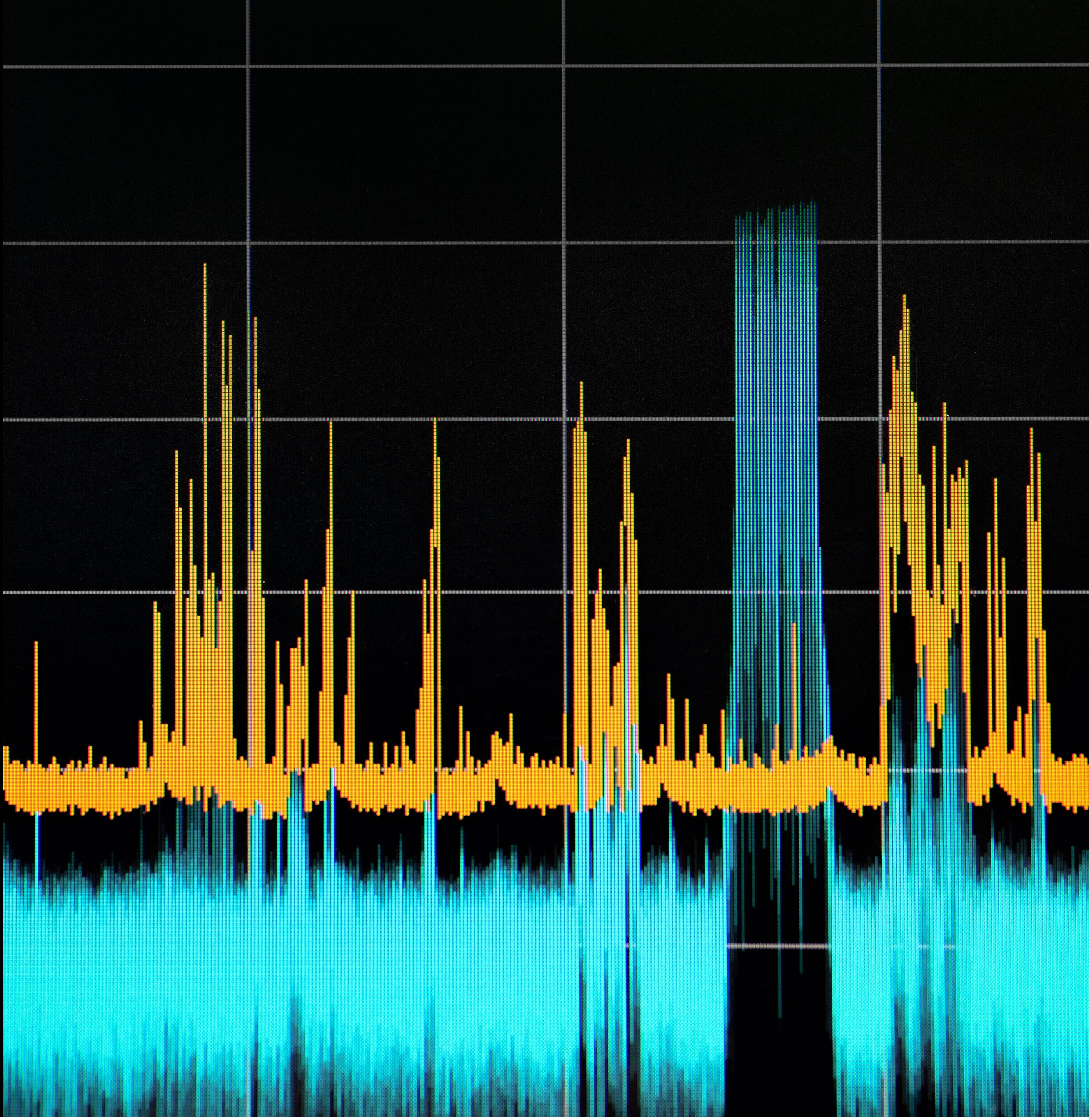


Figure 5. Histogram chart display

CHAPTER 4

Secondary Measurements



Secondary Measurements

Traditionally, DMMs have been single-measurement instruments. In some cases, however, engineers need to monitor more than one parameter from a signal. Tracking a secondary parameter provides complementary data that can make it easier to interpret results and diagnose issues.

With the right architecture and design, DMMs can now make secondary measurements. One example where this might be useful is when measuring temperature using a thermistor connected to a DMM. Discrepancies in the temperature reading might prompt an engineer to also monitor the sensor's resistance to ensure it is within the specified range.

Another example is when measuring a noisy signal, an engineer may want to view both the DC and AC components at the same time. Table 2 shows a list of the secondary measurement functions available on the Keysight Smart Bench Essentials and Advanced DMMs.

Figure 6. Secondary measurement display on a Smart Bench Essentials Plus DMM

Table 2. Seconday measurement functions

DMM primary measurement functions	SBE Education DMM (EDU34450A) secondary measurement functions	SBE Plus DMMs (DM34460A / 61A) secondary measurement functions	Advanced DMMs (34465A / 70A) secondary measurement functions
DCV	ACV, DCI, ACI	ACV, peak, pre-math	ACV, peak, pre-math
ACV	DCV, DCI, ACI, frequency	DCV, frequency, pre-math	DCV, frequency, pre-math
2-wire, 4-wire resistance		Pre-math	Pre-math
DCI	DCV, ACV	ACI, peak, pre-math	ACI, peak, pre-math
ACI	DCV, ACV, frequency	DCI, frequency, pre-math	DCI, frequency, pre-math
Frequency	ACV, ACI	Period, ACV, pre-math	Period, ACV, pre-math
Period		Frequency, ACV, pre-math	Frequency, ACV, pre-math
Temperature		Sensor, pre-math	Sensor, pre-math
Ratio		Input / ref, pre-math	Input / ref, pre-math
Capacitance		Pre-math	Pre-math
Continuity		None	None
Diode		None	None

1. Smart Bench Essentials (SBE)

CHAPTER 5

Simple DC Power Measurements

Simple DC Power Measurements

Many applications require power measurements. For decades, the DMM has been the go-to instrument when a dedicated power meter isn't available. While DMMs can measure both current and voltage, their internal design topology prevents them from measuring both at exactly the same time. However, with the right technique, you can still get good voltage (V) and current (I) measurements from your benchtop DMM.

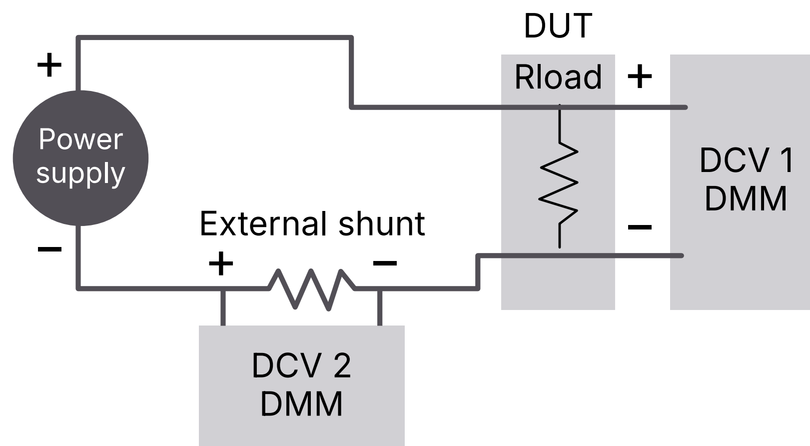
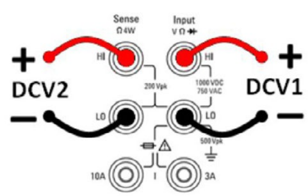


Figure 7. Setup diagram of how a DMM simultaneously measures voltage and current across a device under test (DUT)

One method is to use a math function. If you know the voltage is going to remain stable, you can program your DMM to multiply the known (previously measured) voltage value by the measured current value. Since power equals voltage multiplied by current, you will get a power value in watts displayed on the DMM.



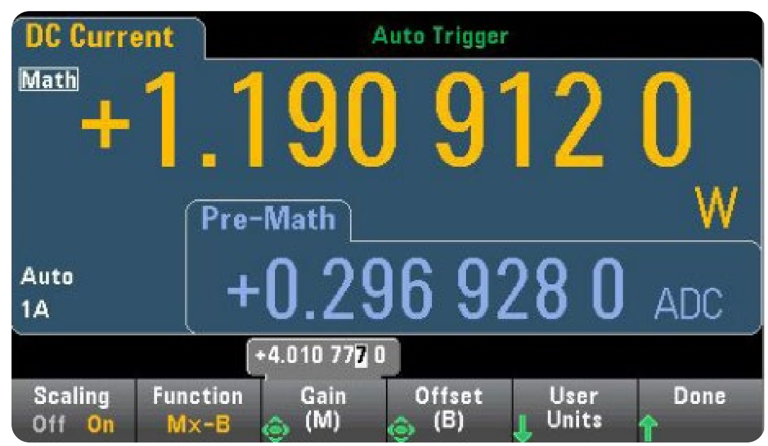
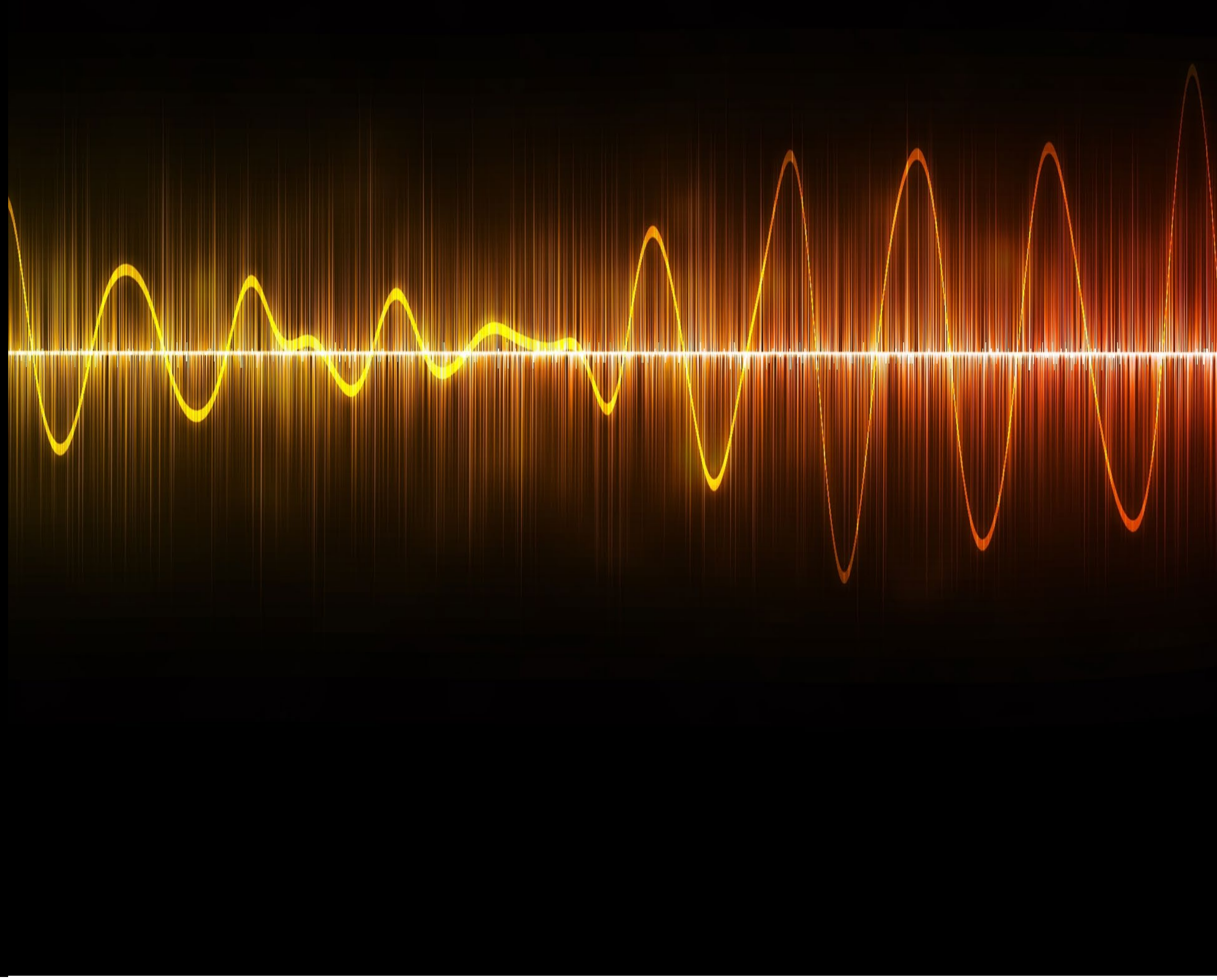


Figure 8. Setup diagram on power measurement using a DMM

Another method is the simultaneous measurement of voltage and current. Many Keysight DMMs have a special feature that enables this. If the sense terminals are not in use, they can be configured to measure a secondary voltage in a circuit while the primary terminals are measuring across a 1 Ω resistor in series with the load. This provides you with simultaneous voltage and current measurements. Some restrictions do apply, but for basic power measurements, this is a handy feature.

CHAPTER 6

Low Current and Dynamic Current Measurements



Low Current and Dynamic Current Measurements

When selecting your next DMM, consider the range of current measurements you need to perform. Semiconductor device testing, for example, requires much greater current measurement accuracy than other applications. Most 6.5-digit DMMs have a minimum current in the milliampere level, which can be a limitation in low-current work.

Burden voltage can also be an issue when measuring low current. Burden voltage is the voltage drop across a shunt resistor in series with a circuit. This is a concern when you want to measure very sensitive components. In some cases, you can offset the burden voltage by setting the voltage slightly higher on your power source.

For applications where ultra-low current measurements are critical, the more advanced Keysight DMMs extend the low-current measurement range to the microampere level with picoampere resolution.

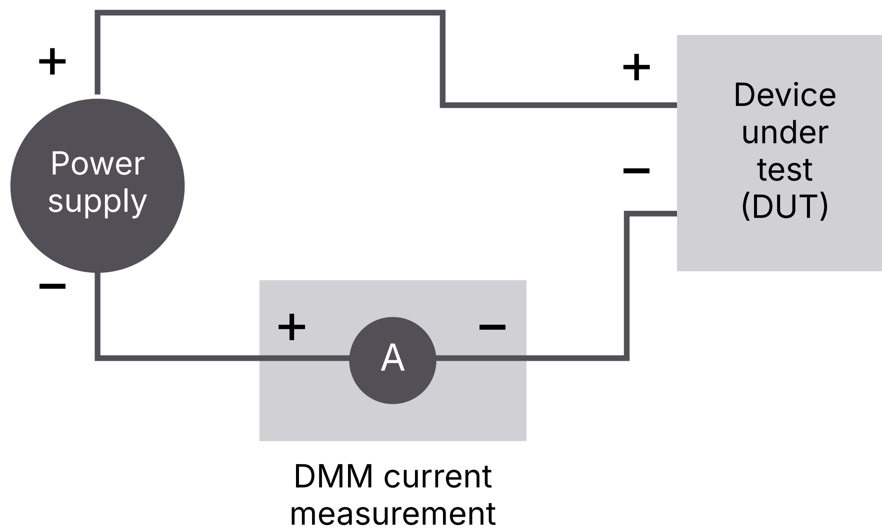


Figure 9. Shown here is the DMM in series measuring current on the return path of the electrical circuit

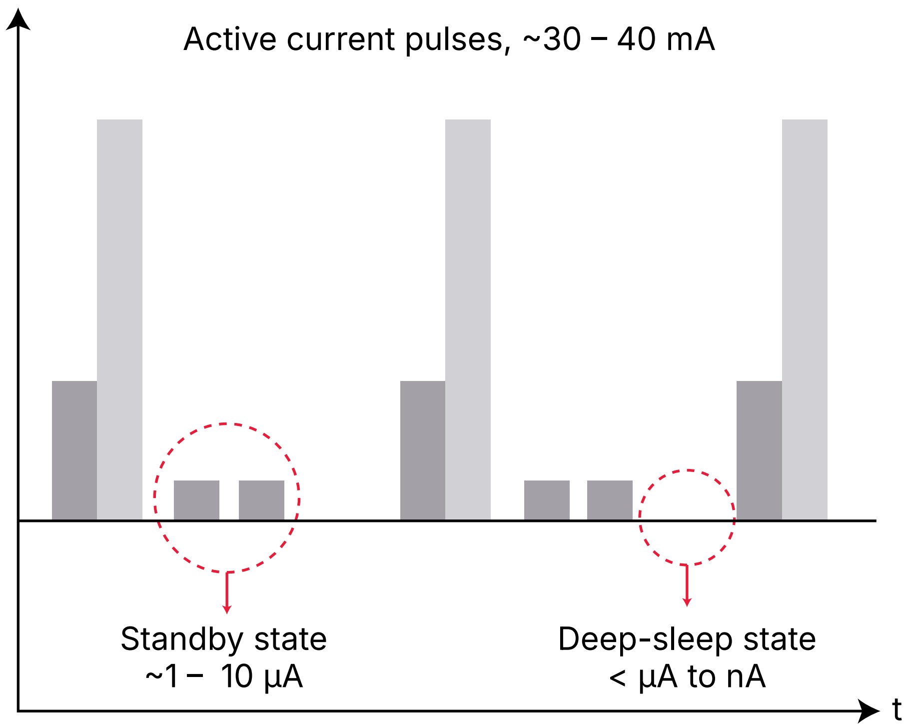


Figure 10. Current profile of a portable radio transceiver

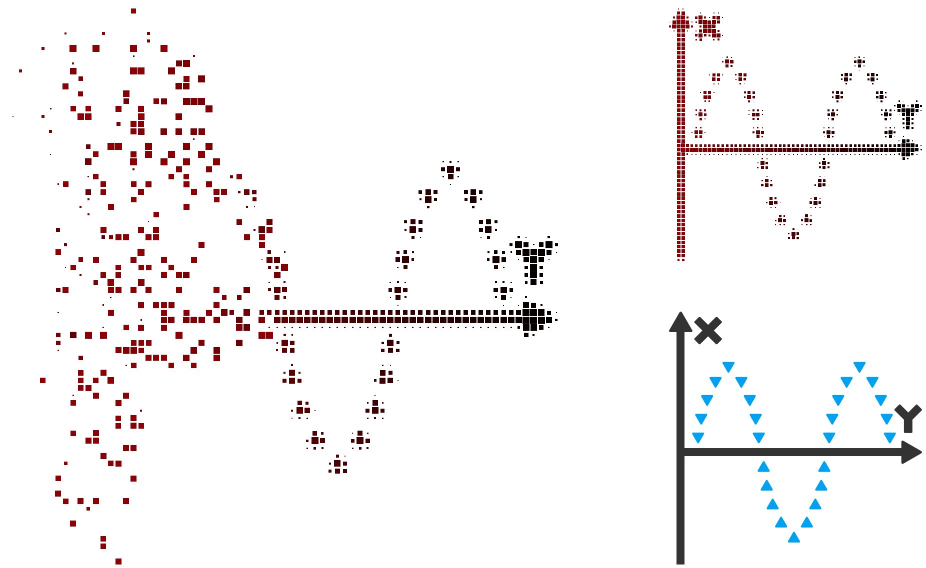
Dynamic current measurements can be complicated, especially when they involve a change in measurement range. Figure 10 shows a typical current profile of a portable radio transceiver, with distinct sleep, standby, and active modes. The dynamic range of the current is large because the operating currents are drawing approximately 30 to 40 mA, while the standby currents drop to 1 to 10 µA. To get accurate readings across both ranges with a DMM, you need to take multiple measurement sweeps at different ranges. One method for capturing the current profile would be to run the device many times to capture the sleep and standby modes separately from the operating mode currents. It is also worth noting that most DMM measurements are not seamless, even if they are autoranging. As a result, a DMM may miss measurement points on a fast, dynamically changing current waveform.

CHAPTER 7

Measuring Difficult AC Signals

Measuring Difficult AC Signals

When thinking about an AC voltage signal, we typically imagine a perfect sinusoidal waveform. In the real world, however, AC voltage signals and currents are never perfect — they come in widely varying shapes and values. Digitizing a waveform lets you view a few cycles, but if you want to track root mean square (RMS) amplitude or frequency over time, you need to make AC measurements. An important component in these measurements is the crest factor, which is the ratio of a waveform's peak value to its RMS value.



In a DMM, the crest factor indicates how much of the waveform's peak energy is included in the AC measurement. Including as much of this energy as possible ensures an accurate measurement. The crest factor also describes the dynamic range of an input signal. For example, if a DMM has a crest factor rating of 10, you can measure an input signal whose peak value is 10 times larger than the rated range value.

Another area where crest factor is important is when you measure pulsed signals, where high peaks may be followed by periods of no activity. In such cases, accurately determining RMS voltage or current can be challenging without a suitable crest factor capability.

CHAPTER 8

Temperature Variations and Auto Calibration

Temperature Variations and Auto Calibration

If you look at a DMM datasheet, you will normally find 90-day and 1-year specification columns. These columns display accuracy as ± (percentage of reading + percentage of range), based on DC voltage of the your specific measurement.

Table 3. Datasheet example

Specification ± (% of reading + % of range)

Range	24 hours T_{ACAL} ± 1 °C	90 days T_{ACAL} ± 2 °C	1 year T_{ACAL} ± 2 °C	2 years T_{ACAL} ± 2 °C	Non ACAL temperature coefficient/°C	With ACAL temperature coefficient/°C
DC voltage: 34465						
100 mV	0.0030 + 0.0030	0.0040 + 0.0035	0.0050 + 0.0035	0.0065+ 0.0035	0.0005 + 0.0005	0.0002 + 0.0005
1 V	0.0015 + 0.0004	0.0025 + 0.0004	0.0035 + 0.0004	0.0050 + 0.0004	0.0005 + 0.0001	0.0002 + 0.0001
10 V	0.0010 + 0.0003	0.0020 + 0.0004	0.0030 + 0.0004	0.0045 + 0.0004	0.0005 + 0.0001	0.0002 + 0.0001
100 V	0.0020 + 0.0006	0.0035 + 0.0006	0.0040 + 0.0006	0.0055 + 0.0006	0.0005 + 0.0001	0.0002 + 0.0001
1000 V	0.0020 + 0.0006	0.0035 + 0.0006	0.0040 + 0.0006	0.0055 + 0.0006	0.0005 + 0.0001	0.0002 + 0.0001

Table 3 shows an example datasheet. The inclusion of 24-hour, 90-day, 1-year, and temperature coefficient (TC) columns is common for high-end DMMs.

If the ambient temperature where you use a DMM to make measurements differs from the temperature at which it was calibrated, you need to consider the TC adjustment. For example, a unit calibrated at 22 °C but operating at 40 °C inside a test rack will be affected by a temperature rise — a common occurrence in enclosed systems. In such cases, the TC specification should be used to add the appropriate error adjustment.

Some high-end DMMs include an auto calibration (ACAL) or self-calibration feature to significantly reduce temperature drift error by automatically compensating for both temperature changes and internal measurement errors. This is a particularly useful capability to look for if you are working in an environment where the ambient temperature is outside the recommended operating range.

CHAPTER 9

Advanced Triggering

CHAPTER 9

Advanced Triggering

Advanced triggering can improve measurement throughput by eliminating the need to insert fixed delays. Instead, triggers enable you to start capturing data when a specific event occurs. Common trigger sources include these:

- Continuous: external triggers such as BNC or bus signals.
- Level: triggered when the input signal crosses a certain threshold.
- Slope: triggered when the signal has a positive or negative slope.

In most advanced DMMs, after trigger detection, you can program a trigger delay and capture multiple sample periods. The results are digitized, stored, and displayed on the screen for detailed post-analysis.

Advanced triggering in digital multimeters enables engineers to capture precise, efficient, and repeatable measurements. By starting measurements only when specific signal conditions are met, it supports delayed and burst sampling and eliminates unnecessary delays to improve throughput. Triggering accurately captures fast or intermittent signals, giving engineers better control, enhanced reliability, and higher productivity — making it a critical feature for modern electronic testing and troubleshooting.

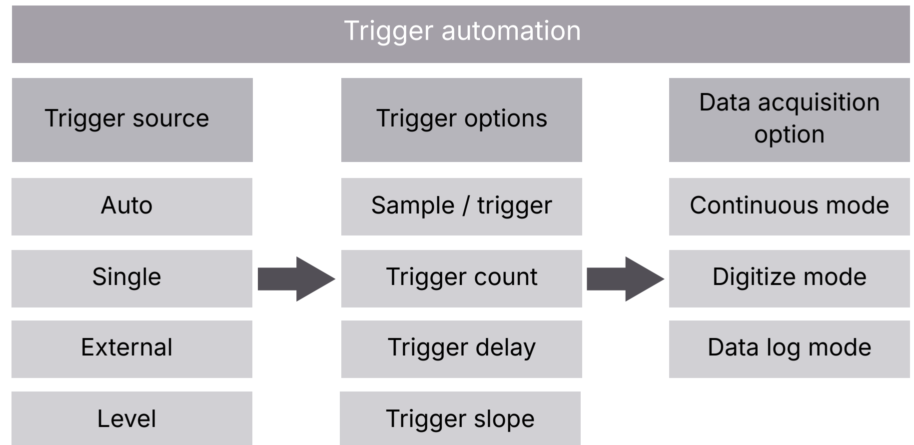
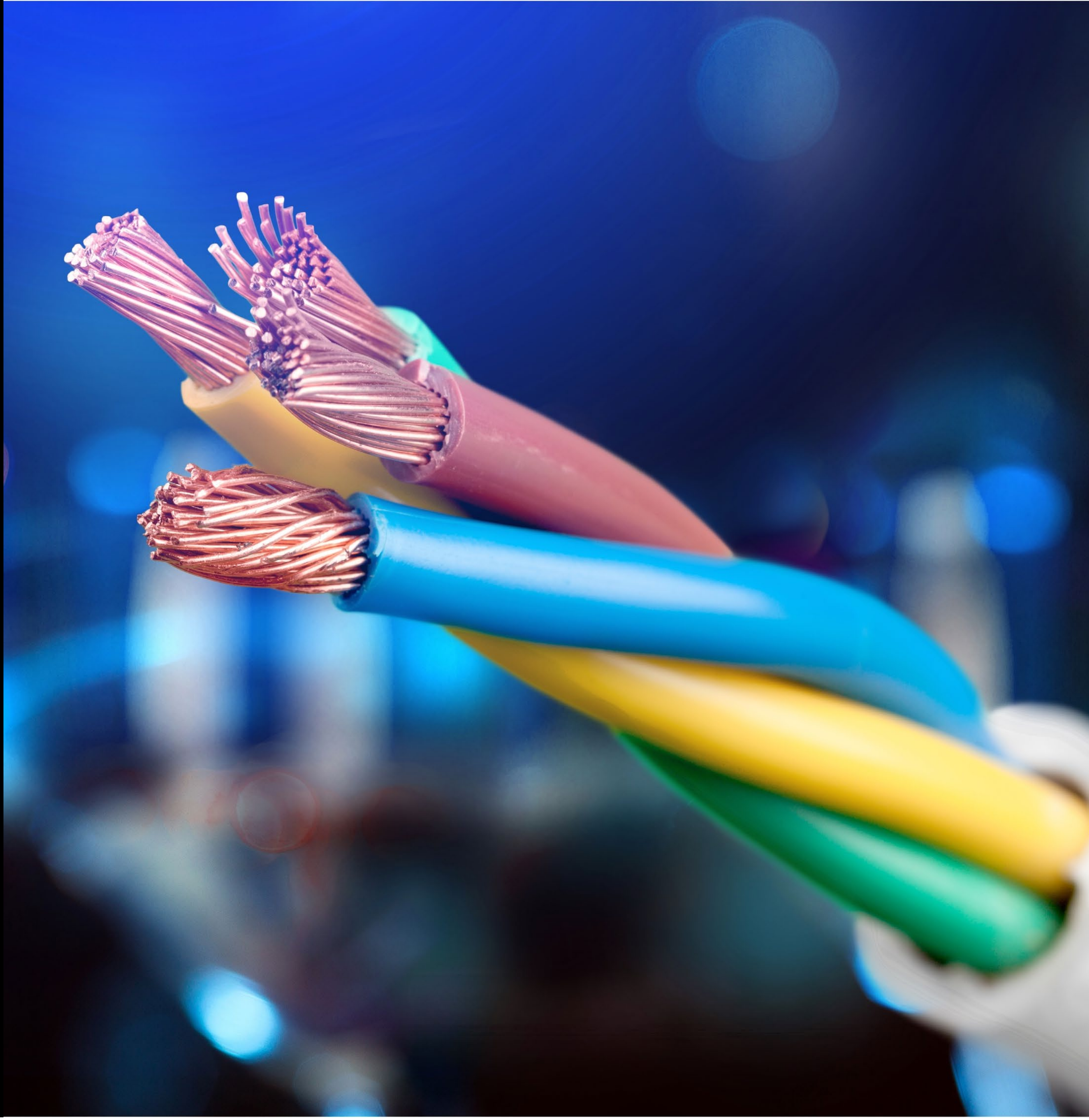


Figure 11. Example of a DMM triggering process and options

CHAPTER 10

Low-Resistance Measurements with Four-Wire Sensing



Low-Resistance Measurements with Four-Wire Sensing

When measuring low resistances, even small lead or contact resistances in a DMM can introduce significant errors. A four-wire (Kelvin) measurement technique solves this by using separate pairs of wires for sourcing current and sensing voltage. Since virtually no current flows through the sense leads, the voltage measured is not affected by lead resistance, resulting in much greater accuracy. This method is especially important when testing components below 10 Ω, such as precision resistors, sensors, or PCB traces. High-performance benchtop DMMs often support four-wire measurements, while most handheld models only offer two-wire. For applications requiring high precision and repeatability, using four-wire sensing ensures that your results truly reflect the resistance of the device under test — not the test setup.

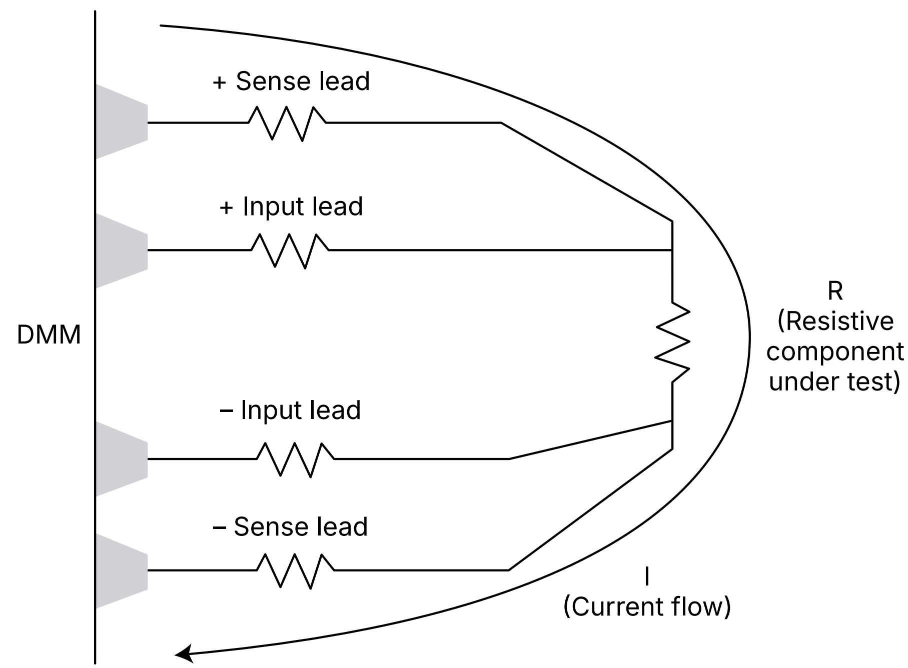


Figure 12. Diagram of lead connections from DMM to a resistive component

Choosing the Right Keysight Benchtop DMM

Your focus is on designing with confidence. Keysight benchtop DMMs are built for reliably accurate measurements every time. Most models feature Truevolt technology, which filters out extraneous noise to deliver true, stable readings with an ideal balance of resolution, linearity, and accuracy.

Choose the resolution that fits your needs:

- Smart Bench Essentials Education — 5.5 digits, 7-inch display
- Smart Bench Essentials Plus — 6.5 digits, 7-inch display, Truevolt technology
- Advanced DMMs — 6.5 to 7.5 digits, 4.3-inch display, Truevolt technology
- You can explore the full range, compare models, and buy directly online at keysight.com

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