

# How to Select a Handheld DMM That is RIGHT for You

## Application Note



## Introduction

Handheld digital multimeters (DMM) are among the most widely used instruments for equipment testing when it comes to servicing, repairing, and installing applications. There are various brands and multiple DMM features in the market to choose from. We are often overwhelmed by many choices and ended up clueless about what we really need in a DMM. This application note will help you get a better picture of each DMMs' operations. It will also guide you in selecting the handheld DMM operations best-suited to your working environment and in choosing a handheld DMM that is designed and tested to protect you against electrical hazards you might encounter.

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Agilent Technologies

## Choosing Your Handheld Multimeter

Let us begin by explaining what a DMM is and how it operates. A DMM is a digital meter that is capable of making various types of measurement. The basic measurements normally include voltage, current, and resistance. DMMs are used to troubleshoot electrical problems in a wide array of industrial and household devices such as batteries, motor controls, appliances, power supplies, and wiring systems.

When it comes to making measurements and choosing a DMM, it is important to be well aware of the test environment and the test requirements. Measuring high-voltage or high-energy sources such as power from mains is an extremely hazardous task, and you need to choose a DMM by looking at more than basic specifications or the size of the handheld. Features and functions and the equipment that you use should be designed with appropriate levels of protection to withstand the electrical hazards in your working environment.

Agilent handheld DMM deliver topnotch world-class performance and provide a wealth of functionality while maintaining portability, ruggedness, and safety compliance. User safety is a primary consideration in the design of Agilent's DMMs, and they provide protection to help you prevent injury and meter damage resulting from improper use. Different handheld DMMs are designed with different levels of protection against common electrical hazards.

Agilent offers many DMMs with different combinations of features to enable you to make fast, safe, and accurate measurements at an affordable price. All handhelds come in vivid orange cases that provide greater visibility and all Agilent handheld product highlight investment protection through feature sets that go beyond those of typical handhelds.

The Agilent U1251A/U1251B Handheld DMM expands your capabilities beyond typical DMM measurements to include data logging. The U1252A/U1251B starts with the same foundation and adds a 20-MHz frequency counter and programmable square-wave generator, so you can perform more tests conveniently with one tool. The U1240A/U1240B Series lets engineers and technicians measure over broad ranges and perform a variety of checks faster with built-in capabilities such as data logging, harmonic ratio, and switch counter. The U1253A is the multiple award-winning world's first OLED handheld DMM that delivers features and value to rival all other DMMs in its class. With this handheld DMM, you would not have to squint to be sure what you are reading; whether on the go or on the bench, you will get crystal-clear viewing indoors, even in dark and off-angle situations. The new U1253B comes in a vivid orange case, offering capabilities and functions equivalent to the U1253A.

Both U1240 and U1250 Series DMMs are housed in robust over-mold enclosures, rated at CAT III 1000 V and CAT IV 600 V, and rated over a wide temperature range of  $-20^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$ . Each DMM also includes a 30 kA high-energy fuse to further protect you against violent fuse failures during high-current measurements. In addition, Agilent provides various types of standard test lead kits and accessories for high current and temperature measurement. IR-to-USB cables to enable PC connection are available to extend the capabilities of DMMs.



## THE BASICS

1. Analog to Digital Converter
2. Resolution
3. Sampling Rate
4. Settling Time

## Basic DMM Operations

### Analog to Digital Converter

The analog-to-digital converter is an important part of the DMM. It not only changes DC voltage to digital information but also defines the capabilities of the DMM such as resolution (digits), sampling rate, and noise reduction. A sigma-delta analog to digital converter is used, and converters oversample the desired signal by a large factor and filter the desired signal band. The converter is a low-powered and linear device and capable of self-calibration.

### Resolution

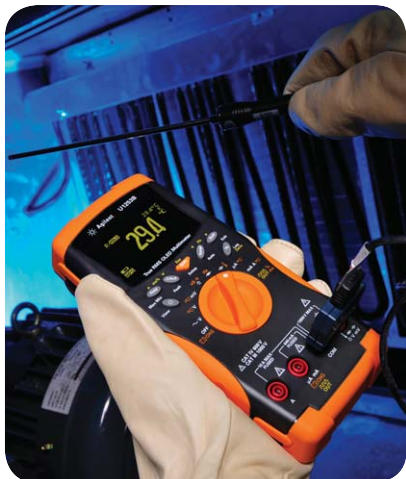
The resolution is the numeric ratio of the maximum displayed value to the minimum displayed value on a selected range. Resolution is often expressed in percentage, parts per million (ppm), counts, or bits. Generally, it is more precise to describe a meter by counts of resolution than by digits. The U1240 Series is a four-digit DMM that can display a measurement with up to 10,000 counts of resolution and with automatic polarity indication. The device comes with 0.09% basic DC voltage accuracy and true RMS measurement. The four-and-one-half-digit U1250 Series gives you greater confidence in your measurements with accurate true-RMS AC measurements, a low DCV error rate of up to 0.025% and a high-resolution display of 50,000 counts.

### Sampling Rate

Sampling rate is defined as how fast the DMM is capable converting the incoming analog signal to digital values. In other words, it is the reading speed of the A/D converter. Both U1240 and U1250 Series DMMs are able to gather seven readings/s for both DC and AC measurements.

### Settling Time

DMM settling time is the total time required for the amplified signals to achieve a specified DMM accuracy limit. Both DC and AC signals need to pass through DMM components such as multiplexers, buffers, amplifier, RMS-to-DC converters (only for AC signals), and analog-to-digital converters. Each component has its own process time. The total settling time is the settling time of all these components. Unlike other DMMs, Agilent DMMs have the ability to insert measurement settling time automatically to ensure the measurement results are accurate. Some DMMs will immediately return readings when a function has been switched without adding any settling time. In this case, the DMM is returning an incorrect value before the stabilized point. When the signal is still ramping up, typically the first few readings from the DMM are not accurate.





## Easy-to-Read Large Digital Display

Troubleshooting can be tricky, especially when you are dealing with elusive problems. Besides the basic specifications and functions, the design of digital display should be one of your purchasing considerations. Agilent handheld DMMs enable you to check more with wider measurement ranges.

The Agilent U1240 Series Handheld DMMs are designed with a dual display (the secondary display is intended for temperature function display only) consists of a four-digit liquid crystal display (LCD) with a maximum reading of 11,000 counts and automatic polarity indication. The handheld is also designed with an adjustable backlighting function (with two intensity levels) that allows you to complete your jobs even in subdued lighting conditions, at the same time prolonging the battery life.

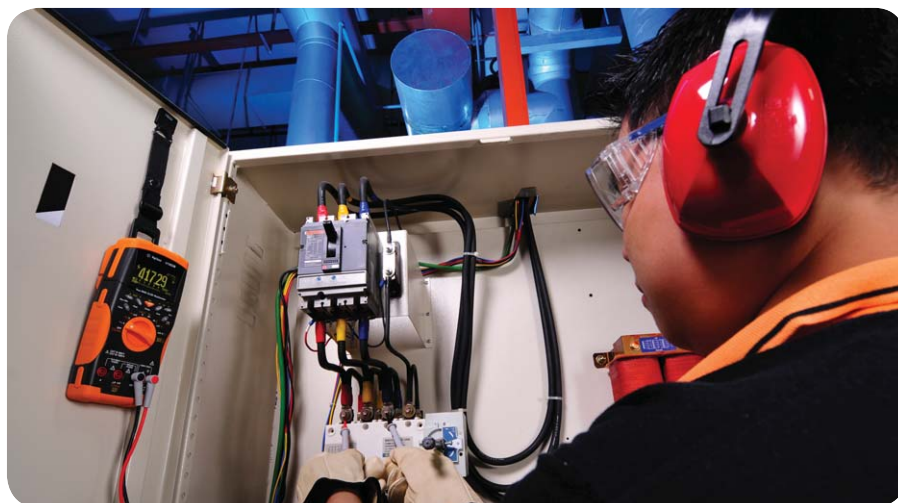


Example of U1242B display



Example of U1253B OLED display

The U1250 Series gets even better. With the new Agilent award-winning U1253A DMM, the world's first organic LED (OLED) handheld DMM, you do not have to squint to ensure that you are reading your measurements correctly. On the go or on the bench, you will get crystal-clear viewing indoors, even in dark and off-angle situations. It is designed with high a contrast ratio of 2000:1 and a wide viewing angle of 160°. You can toggle the large numerical display to dual-display mode, with both displays at 50,000-count high resolution.



## Collect Data with GUI Data Logger Software

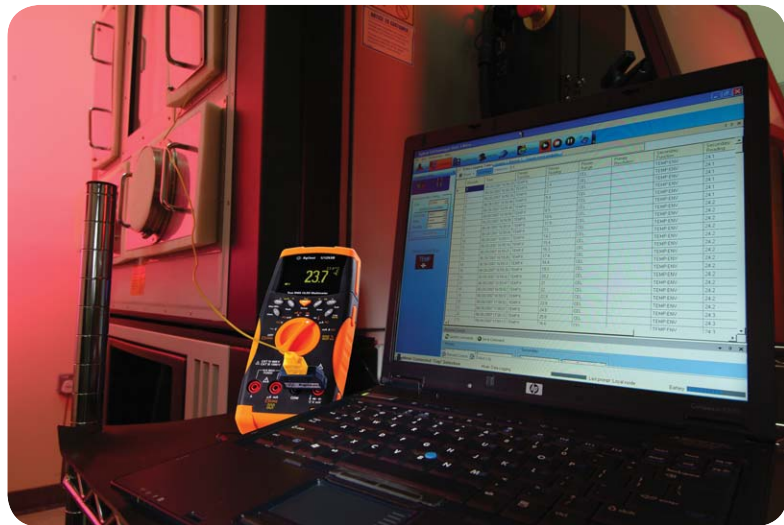
Maintenance personnel from factories can now perform limitless range of troubleshooting, monitoring, and process documentation tasks using the bundled Agilent GUI datalogger free software. The U1240 and U1250 Series with the GUI datalogger software can collect information on general trends and develop an environmental profile of a factory. The data logger can collect data over a week period to support systems such as the installation or repair of heating, ventilation, and air-conditioning (HVAC) systems in a factory.

The GUI datalogger software is able to log and time-stamp up to 10,000 records. It is also capable of displaying two types of parameters, and the DMM is capable of measuring simultaneously. Supported measuring parameters include voltage, current, resistance, frequency, capacitance, inductance, temperature, and diode parameters.

The GUI datalogger provides a simple way of tabulating and plotting acquired data by saving the data to .CSV file format, which can be directly exported into other common applications such as Microsoft® Excel for further data analysis and display.

Data Logging Table						
Shows ▾ Secondary		Directory: ...		Square wave program		
	Records	Time	Primary Function	Primary Reading	Primary Range	Primary Resolution
▶	1	1/25/2010 2:48:28 PM	VOLT	5.00065	5.000	100.0 μ
	2	1/25/2010 2:48:29 PM	VOLT	5.00064	5.000	100.0 μ
	3	1/25/2010 2:48:30 PM	VOLT	5.00063	5.000	100.0 μ
	4	1/25/2010 2:48:31 PM	VOLT	5.00064	5.000	100.0 μ
	5	1/25/2010 2:48:32 PM	VOLT	5.00064	5.000	100.0 μ
	6	1/25/2010 2:48:33 PM	VOLT	5.00059	5.000	100.0 μ
	7	1/25/2010 2:48:34 PM	VOLT	5.0006	5.000	100.0 μ
	8	1/25/2010 2:48:35 PM	VOLT	5.00062	5.000	100.0 μ
	9	1/25/2010 2:48:36 PM	VOLT	5.00057	5.000	100.0 μ
	10	1/25/2010 2:48:37 PM	VOLT	5.00059	5.000	100.0 μ

Figure 1. DC Voltage measurement data logging



## Handheld Multimeter Safety and You

In this section, we will explain how to choose proper handheld DMMs and ensure that your measurement safety is adequate for your application and test environments.

To stay safe, you need to consider three key characteristics when you are selecting a handheld DMM to measure a circuit in a building. The first key characteristic is the voltage rating of the circuit. You need to know the maximum voltage at which the circuit is designed to work. There are many different mains voltage ratings for the operation of household and light commercial electrical appliances and lighting. All European and most South American, African, and Asian countries use supply that is within 10% of 230 V, whereas Japan, North America, and some parts of northern South America use voltages between 100 V and 127 V.

At minimum, you must choose a handheld DMM rated to measure the voltage that is expected to be present on the circuit. However, the circuit voltage rating alone does not tell the whole story. You must also take transient voltages into consideration when selecting a handheld DMM for measurement.

In addition to the transient voltage ratings of circuits, you need to consider the energy capacity of the circuit. To protect yourself, you should know your energy capacity of the circuit before you start taking measurements. Circuits with higher energy capacity can deliver more current and energy into faults than low-energy circuits. Therefore, measurements performed on higher-energy circuits are much more hazardous than measurements performed on lower-energy circuits. The energy capacity of the circuit is generally defined by three characteristics: the operating voltage, the circuit impedance, and the characteristics of the circuit fuse or circuit breaker.

The International Electrotechnical Commission (IEC) has defined three “Measurement Categories” for mains circuits. The higher the category number, the greater the danger posed by transient voltages on the mains circuit. All manufacturers of handheld multimeters are required to mark their products with the rated measurement category (CAT II, CAT III, or CAT IV). This marking is a convenient way for users to identify the maximum transient voltage that the meter can safely withstand. Most handheld multimeters display this rating near the handheld multimeter voltage/current input terminals.

*Table 1. IEC definitions of its measurement categories*

Category	Description
Measurement Category II	This category is applied to all equipment connected from the wall socket up to the equipment’s first level of power conversion. Measurements at the wall socket itself might not be limited to CAT II levels. Handheld DMM should always be capable of CAT III measurements.
Measurement Category III	This category is applied to building circuit installations that are completely within the building, including parts of the service panel and the branch circuits. It also applies to many of the building’s fixed equipment, which is connected directly to the building mains instead of being connected through cords and plugs.
Measurement Category IV	This category is applied to the source of the building’s electrical installation: the entrance service panel, the primary mains meter, or perhaps the secondary side of the building distribution transformer, if the transformer is located within the building.

## Handheld Multimeter Safety and You (continued)

Agilent handheld DMM designs meet the latest and most demanding safety standards. For instance, to measure a 480 V, you can use Agilent U1240 and U1250 Series handheld DMMs. The meters have a high safety rating with CAT III 1000 V and CAT IV 600 V protection and are certified to CE and CSA standards. In addition, every unit is shipped with test probes using 4-mm tips, a length that reduces the likelihood of high-energy sparking, especially in CAT IV environments. As defined by the IEC, CAT III environments include three-phase distribution (and single-phase commercial lighting) while CAT IV environments include three-phase utility connections and outdoor conductors.



While most comparable DMMs use 10 kA fuses, Agilent U1240 and U1250 Series now use 30 kA fuses to provide greater protection from high-voltage transients. During qualification of the 30 kA fuse, all models passed HIPOT testing at 2000 VAC and 2000 VDC between the microamp, milliamp, and ampere terminals and common ground.

Safety certification is important, and responsible manufacturers of handheld DMM like Agilent obtain safety certifications from third-party independent testing agencies such as the Canadian Standard Association (CSA), which evaluate products or systems for compliance with specific requirements.

Before you purchase a new handheld multimeter, remember to check for the symbol of a recognized testing organization. Those symbols can only be used if the product successfully completed testing to the agency's standard, which is based on national/international standards. Normally, you can find this distinctive marking at the back of the meter. Similarly, the multimeter probes should also be marked with a logo of a third-party safety agency.



## Good Measurement Practice

The last important step, once the proper meter has been chosen, is to use it while following measurement procedures. Carefully read the instrument user manual before use, paying particular attention to the WARNING and CAUTION sections.

For further safety information details, refer to the Agilent U1240 and U1250 Handheld Digital Multimeter User's and Service Guides.

## CONCLUSION

Today's handheld DMMs are widely used in servicing, repairing, and installing tasks. Choosing a proper handheld product has become more complex than ever before. Besides the product's electrical specifications and features, the product safety features and safety specifications should be important purchasing considerations when you deal with main power or high-voltage measurements.

Agilent's handheld DMMs are designed with many features and capabilities and perform with high accuracy in application and test environments, while meeting the latest and most demanding safety standards.

## REFERENCES

- U1241B and U1242B Handheld Digital Multimeter User's and Service Guide - Literature # U1241-90063
- U1251B and U1252B Handheld Digital Multimeter User's and Service Guide - Literature # U1251-90036
- U1253B True RMS OLED Multimeter User's and Service Guide - Literature # U1253-90035

## RELATED AGILENT LITERATURE

- Think SAFETY When Selecting a Handheld Multimeter - 5990-4578EN

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