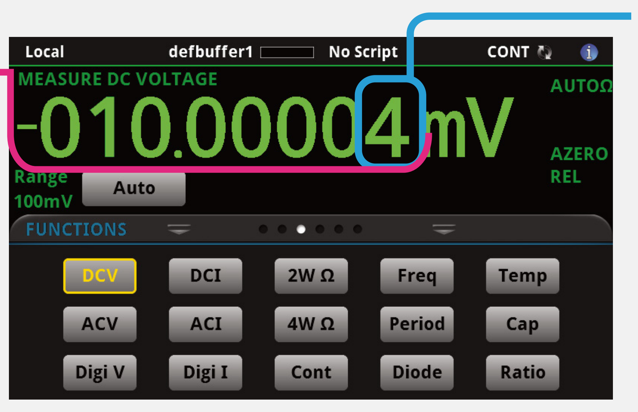
TOP 5 Digital Multimeter User Questions

Answers and Antidotes from Our Panel of Application Engineers

1 What's the difference between **sensitivity, resolution,** and **accuracy?**

RESOLUTION

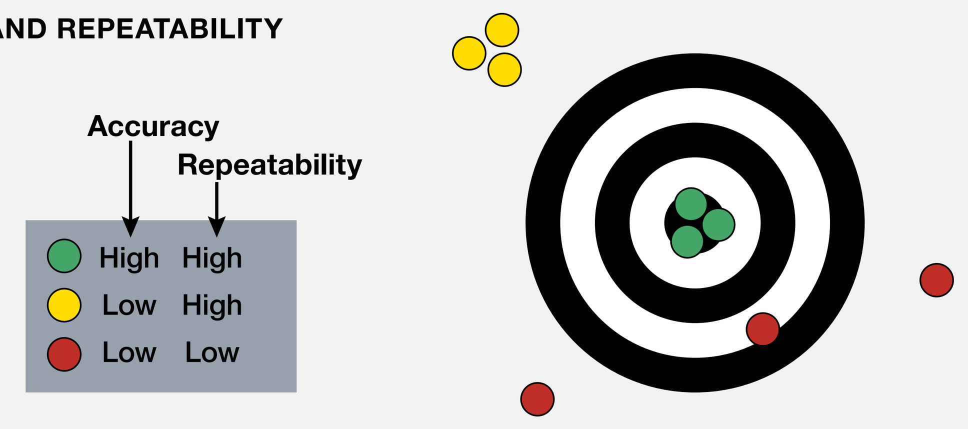
The smallest portion of the signal that can be measured and displayed on any range. The resolution on this Model DMM7510 7.5-digit DMM, 100mV range is 10nV. On the 1V range it is 100nV.



SENSITIVITY

The smallest change in the input signal that can be detected. On the 100mV range, this DMM is capable of sensitivity down to tens of nanovolts (nV).

ACCURACY AND REPEATABILITY

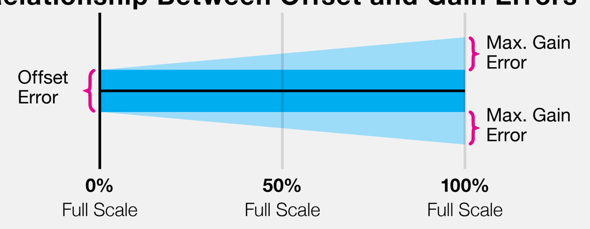


ABSOLUTE AND RELATIVE ACCURACY

Absolute Accuracy: A measure of the closeness of agreement between a measured value and that of a primary standard value.

Relative Accuracy: A measure of the closeness of agreement between a measured value and that of a locally referenced standard value.

Relationship Between Offset and Gain Errors



Specification Conversion Chart

Percent	PPM	Digits	Bits
10%	100000	1	3.3
1%	10000	2	6.6
0.1%	1000	3	10
0.01%	100	4	13.3
0.001%	10	5	16.6
0.0001%	1	6	19.9
0.00001%	0.1	7	23.3
0.000001%	0.01	8	26.6
0.0000001%	0.001	9	29.9

DMM Accuracy Specifications are given as % or PPM of reading (Gain) and range (Offset).

= ±(PPM of Reading + PPM of Range)

OR = ±(% of Reading + % of Range)

= ±(Gain Error + Offset Error)

Accuracy
= ±(14ppm of reading + 1.2ppm of range)
= ±(0.0014% of reading + 0.00012% of range)

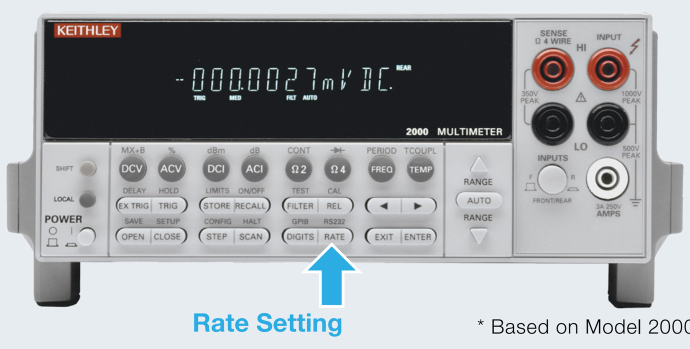
Uncertainty @ 5V
= ±5(0.0014%) + 10(0.00012%)
= ±(0.00007 + 0.000012)
= ±0.000082V or ±82µV

* Specification for Keithley Model DMM7510, 10V Range, 1PLC, 1 Year.

2 How do I make my DMM **measure faster?**

COMMON SPEED ADJUSTMENTS

- **Measure Rate**: Also called Aperture, NPLC, or Rate.
- **Ranging Mode:** Auto or Fixed (Manual).
- **Filtering:** Moving average or repeating.
- **AutoZero:** On, Off, Once.

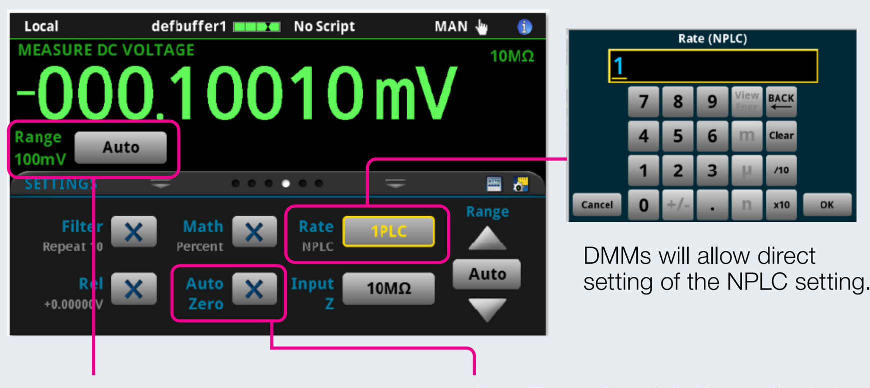


* Based on Model 2000.

MEASURE RATE: USING DMM RATE SETTING

- **FAST** sets integration time to 0.1 PLC. Use FAST if speed is of primary importance (at the expense of increased reading noise and fewer usable digits).
- **MEDIUM** sets integration time to 1 PLC. Use MEDIUM when a compromise between noise performance and speed is acceptable.
- **SLOW** sets integration time to 10 PLC. SLOW provides better noise performance at the expense of speed.

MEASUREMENT RATE: USING DMM APERTURE/NPLC SETTING



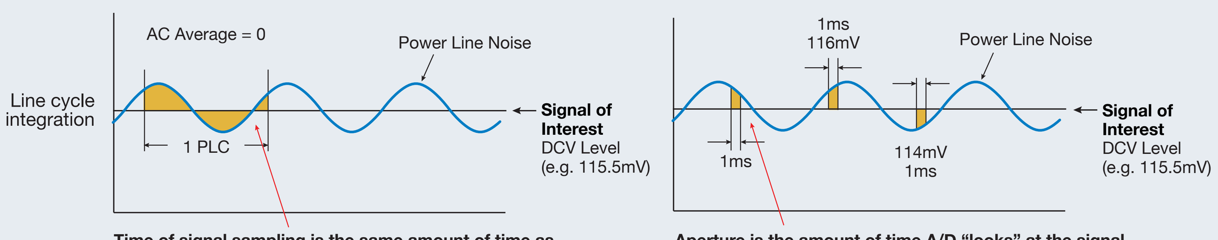
DMMs will allow direct setting of the NPLC setting.

Ranging Mode: When set to "Auto", will limit measurement speed since the DMM must first determine if a range change is needed. Utilizing a fixed manual range will often accelerate measurements.

AutoZero: On, Off, Once. Optimizes measurement sampling between the user DUT and internal references to create the most accurate measurement. When disabled, measurement sampling is only performed on the DUT, therefore sacrificing accuracy for faster measurement times.

WHAT IS NPLC?

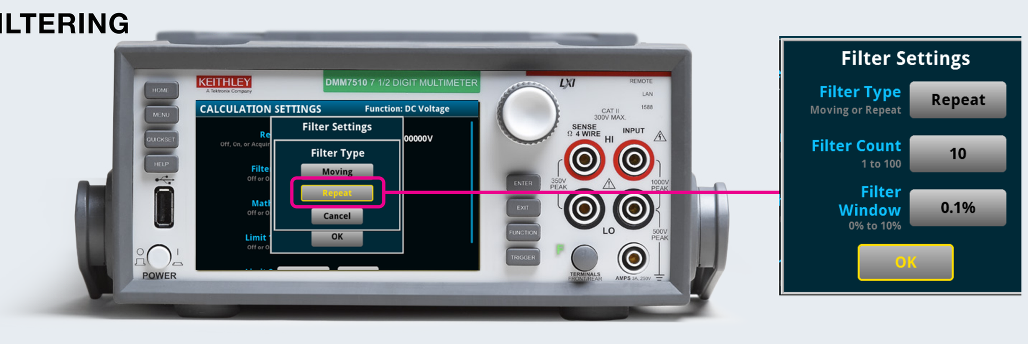
NPLC is the number of power line cycles and represents the duration of signal sampling. Using integer multiples of NPLCs results in the most accurate measurement, but you are limited to power line cycle frequency (1 PLC = 60 readings/s @ 60Hz or 50 readings/s @ 50Hz).



Time of signal sampling is the same amount of time as 1 power line cycle. Therefore, average of noise is zero.

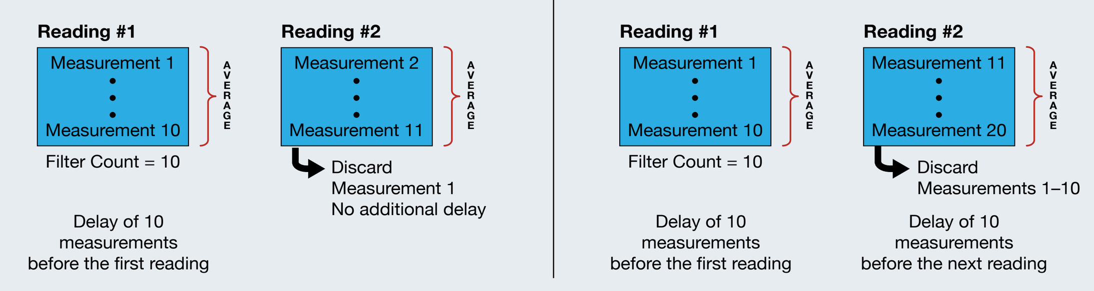
Aperture is the amount of time A/D "looks" at the signal. In this case, it is a fraction of the power line cycle and, therefore, noise is included in the measurement.

FILTERING



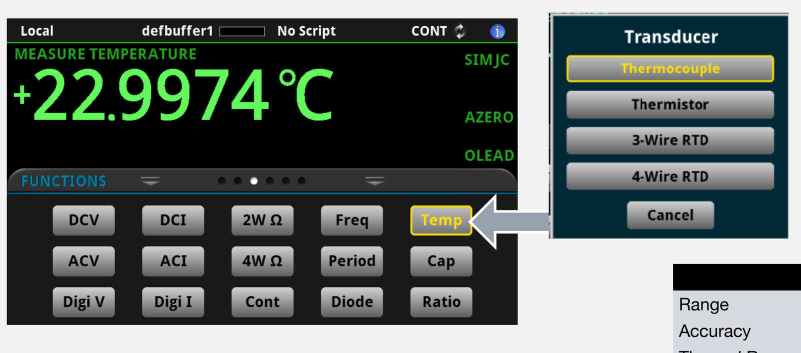
A *moving* filter will only delay the *first* reading by the number of user selected filter counts.

A *repeat* filter will delay *each* reading by the number of user selected filter counts.



3 Which **temperature sensor** should I use?

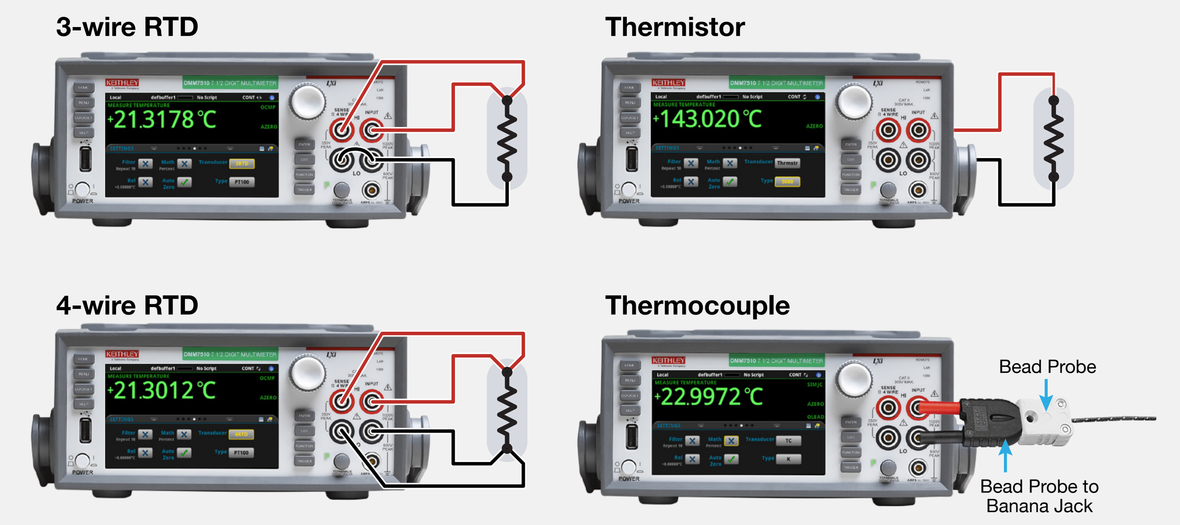
Modern DMMs often allow multiple temperature sensors to be connected.



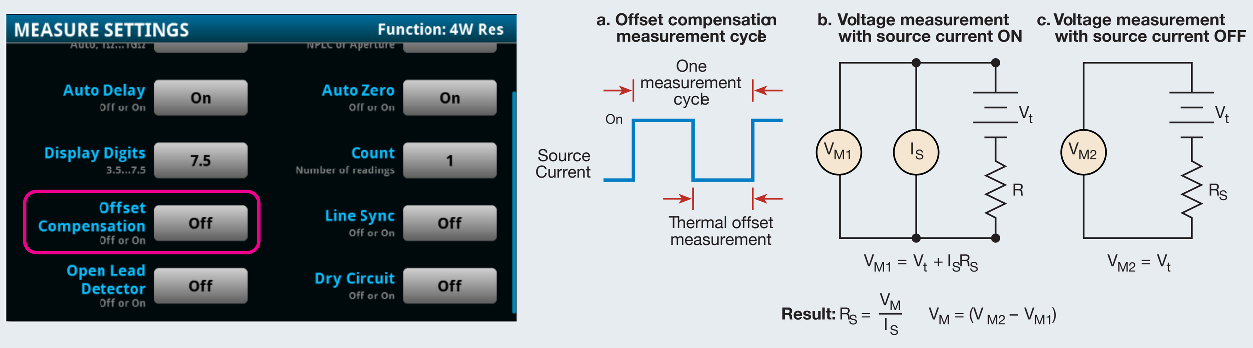
The most common sensors used are type J, K, T, and E thermocouples. Common trade-offs are shown below.

	Thermocouple	RTD	Thermistor
Range	−200°~2000°C	−250°~850°C	−100°~300°C
Accuracy	>1°C	0.03°C	0.1°C
Thermal Response	Fast	Slow	Medium
Cost	Low	High	Low to moderate
Long Term Stability	Low	High	Medium

THERMOCOUPLE, RTD, AND THERMISTOR CONNECTIONS



5 What are **offset compensation** and **dry circuit mode?**



$V_{M1} = V_t + I_S R_S$ $\quad V_{M2} = V_t$

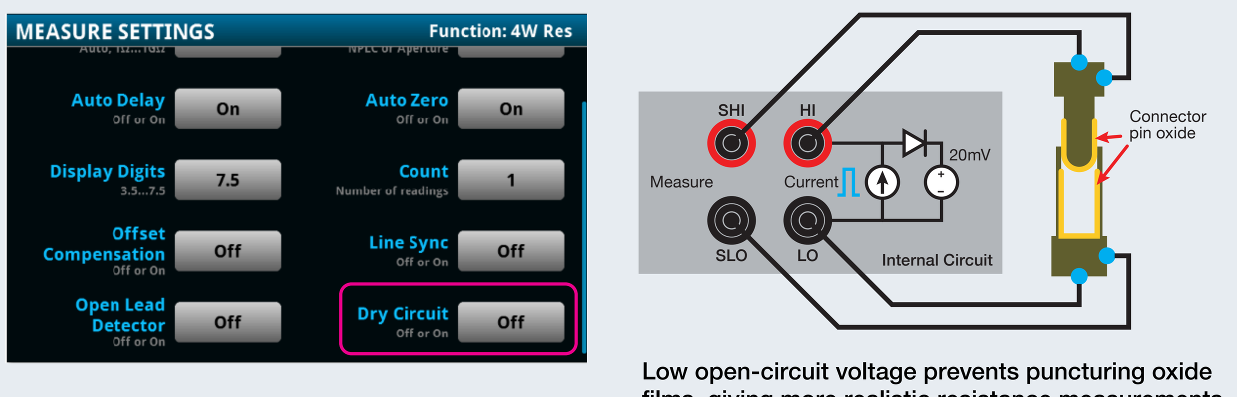
Result: $R_S = \frac{V_M}{I_S}$ $\quad V_M = (V_{M2} - V_{M1})$

OFFSET COMPENSATION is the name of one technique that eliminates thermal voltage errors when measuring low resistances (typically below 10Ω). Resistance is measured by sourcing a current, measuring the resultant voltage, and then using Ohms' Law to calculate the unknown resistance.

In the offset compensation technique, the source current is alternated on and off and voltage measurements are made during both portions of the cycle. When the source current is on, the voltage measured is both the thermal error voltage and the voltage across the device under test, as shown in part b of this figure. When the source current is off, there is no current through the device under test, and so the voltage measured is just the thermal error voltage as shown in part c.

Therefore, the voltage measured in part c can be subtracted from the voltage measured in part b. The correct resistance can be calculated using this voltage VM and the level of source current during the on portion of the cycle. The technique is very useful as long as the thermal voltage error is not changing between the time that the source current is cycled on and off.

DRY CIRCUIT



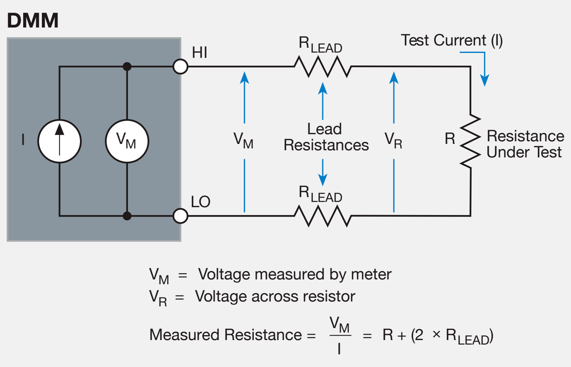
Low open-circuit voltage prevents puncturing oxide films, giving more realistic resistance measurements in connectors, relays, µP sockets, etc.

DRY CIRCUIT ohms limits open-circuit voltage levels to 20mV (typical levels are on the order of 6 to 14 volts depending on the range) to minimize any physical and electrical changes in a measured contact junction. This low open-circuit voltage will not puncture the film, and will therefore provide a resistance measurement that includes the resistance of the oxide film. Dry circuit ohms can be used on the 1Ω, 10Ω, 100Ω, 1kΩ, and 10kΩ ranges (maximum resistance of 2.4kΩ) for the 4W function only.

4 When and why do I need to use the **four-wire resistance measurement** function?

Resistance measurements are very commonly performed using bench multimeters. Many multimeters will include both two- and four-wire methods. The **two-wire method should only be used when measuring resistance values beyond 10 Ohms** because of the impact of lead resistance, which can add significant error (1% or more). **The solution for more accurate low resistance measurements is the four-wire** (also called Kelvin) connection method. This solution minimizes the impact of lead resistance by automatically removing the effect of lead resistance. With this configuration, the test current (I) is forced through the test resistance (R) via one set of test leads, while the voltage (VM) across the DUT is measured through a second set of leads (sense leads). Although some small current (typically less than 100pA) may flow through the sense leads, it is usually negligible and can generally be ignored for all practical purposes. The voltage drop across the sense leads is negligible, so the voltage measured by the meter (VM) is essentially the same as the voltage (VR) across the resistance (R). As a result, the resistance value can be determined much more accurately than with the two-wire method.

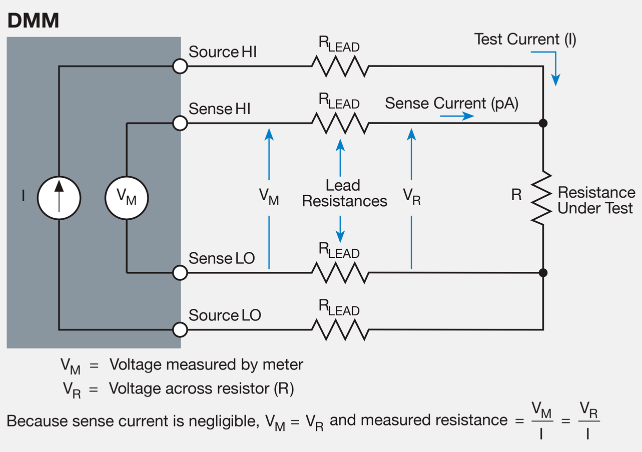
Setup for a typical two-wire resistance measurement.



V_M = Voltage measured by meter
V_R = Voltage across resistor

Measured Resistance = $\frac{V_M}{I}$ = $R + (2 \times R_{LEAD})$

The effect of test lead resistance can be reduced using the four-wire (Kelvin) connection method.



V_M = Voltage measured by meter
V_R = Voltage across resistor (R)

Because sense current is negligible, $V_M = V_R$ and measured resistance = $\frac{V_M}{I} = \frac{V_R}{I}$

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