8 Hints

for Making Better Digital Multimeter Measurements

Agilent Technologies

Hint 1

Avoid measurement errors caused by connections, test leads or wires

The simplest way to remove errors caused by connections and wires is to make a null measurement. For a DCV or resistance measurement, select the appropriate range for the measurement, then connect the probes together and wait for a measurement—it should be pretty close to zero—then press the null button. Subsequent readings will subtract the null measurement. Null measurements tend to work well for both DC and resistance measurements. Unfortunately, this technique does not work for AC measurements. AC converters are not designed to work at the lowest part of the range; the Agilent 34401A digital multimeter's analog converter is not specified below 10% of full-scale. Agilent's 34410A and 34411A multimeters use a digital technique and can measure down to 1% of full scale, but they are not designed to measure a short.

Connections

When you make connections with dissimilar metals, a thermocouple junction is formed. A thermocouple junction produces a voltage that changes with temperature. The voltage created is small, but it needs to be addressed if you are measuring small voltages or your system has many connections. Junctions to consider are at the DUT, at relays (multiplexers), and at your multimeter. Using copper-to-copper junctions will help minimize offsets.

When you make resistance measurements, you can use offset compensation to measure any offset voltage and remove the error. Figure 1 illustrates the two measurements used in offset-compensated measurements, one with the current source and a second without the current source. Subtracting the second measurement from the first and dividing by the known current source will give you the actual resistance. Since two measurements are made per reading, reading speed will be reduced, but accuracy will be improved. Offset compensation can be used in both two- and four-wire measurements.
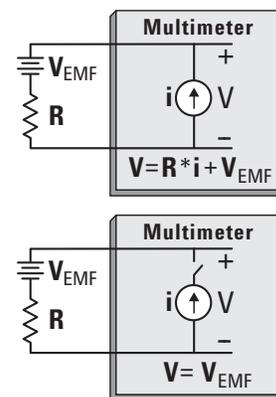
Figure 1

Offset compensation using two measurements. The first measurement is a standard ohm measurement; the second one measures the offset generated by thermal EMF. The meter reading is the difference between the two measurements divided by the known current source.

Leads

The four-wire ohms method is the most accurate way to measure small resistances. Test-lead resistances and contact resistances are automatically reduced using this method. The connections for four-wire resistance measurements are shown in Figure 2. Using a known current source and measuring the voltage produced by the resistor, the unknown resistance can be calculated. The additional set of leads carries the current to the unknown resistor, which creates a voltage that can be measured through the voltage sense leads. No current flows through the voltage sense leads, so no additional voltage drop is created in these leads.
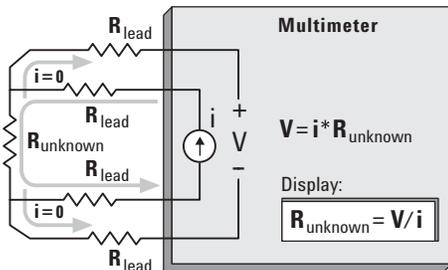
Internal multimeter offsets

Autozero is used to remove sources of error within the multimeter. When autozero is enabled, the multimeter internally disconnects the input signal following each measurement and takes a zero reading. It then subtracts the zero reading from the preceding reading. This prevents offset voltages present on the multimeter's input circuitry from affecting measurement accuracy. Autozero is always enabled for four-wire measurements, but you can disable it for two-wire measurements to increase measurement speed.

When autozero is disabled, the multimeter takes one zero reading and subtracts it from all subsequent measurements. It takes a new zero reading each time you change the function, range, or integration time.

R_{lead}
$i = 0$
R_{lead}
$R_{unknown}$
R_{lead}
$i = 0$
R_{lead}

Multimeter

i $+$
V
$-$

$V = i * R_{unknown}$

Display:

$R_{unknown} = V / i$

Figure 2

No current flows through the voltage sense leads. The multimeter divides the measured voltage by the known current to determine the unknown resistance.

Settling time effects

A capacitance in parallel with a resistor causes settling time errors after an initial connection and after a range change. Modern multimeters insert a trigger delay to allow time for the measurement to settle. The length of the trigger delay is dependent on the selected function and range. While these delays are adequate for resistance measurements with less than a few hundred pF of combined cable and device capacitance, the default delays may not be adequate if the resistor has a parallel capacitance or you are measuring resistances above 100 kΩ. Settling due to RC time constant effects can be quite long. Some precision resistors and multi-function calibrators use parallel capacitors (1000 pF to 100 µF) with high resistor values to filter out noise currents injected by their internal circuitry. Non-ideal capacitances due to dielectric absorption (soak) effects in cables and other devices may increase the RC time constant and require much longer settling times. You may need to increase the trigger delay before making a measurement in these situations.

Offset compensation when a capacitance is present

If a resistor has a parallel capacitance, it may be desirable to turn off offset compensation. When offset compensation makes a second reading without the current source on, it will measure any voltage offsets. However, if a device has a long settling time, it can create an erroneous offset measurement. The multimeter will apply the same trigger delay to the offset measurement in an attempt to avoid settling time issues. Increasing the trigger delay so the device is fully settled is another solution.

Connections in high-resistance measurements

When you are measuring large resistances, significant errors can be caused by insulation resistance and surface contamination. Take the necessary precautions to maintain a "clean" high-resistance system. Test leads and fixtures are susceptible to leakage caused by moisture absorption in insulating materials and "dirty" surface films. Nylon and PVC are relatively poor insulators (10^9 ohms) compared to PTFE Teflon insulators (10^{13} ohms). Leakage from nylon or PVC insulators can easily contribute a 0.1% error if you measure a 1 MΩ resistance in humid conditions.

Hint

Making an AC measurement with a DC offset

Many signals contain both an AC and a DC component. For example, an asymmetric square wave contains both components. Many audio signals contain a DC offset created by the DC bias current that drives the output transistors. In some cases it is desirable to measure both the DC + AC voltage, while in others, you may want just the AC component. For this audio example, the amplifier gain would compare the input AC voltage to the output AC voltage.

Most modern multimeters use a DC blocking capacitor in front of the AC RMS converter. Blocking the DC voltage allows the multimeter to measure just the AC value. More importantly, the multimeter can scale the AC signal for the best possible measurement. For example, when measuring the AC ripple of a power supply, the multimeter blocks high-level DC signal but can amplify the AC signal by selecting the range based on just the AC component.

To make the most accurate AC+DC measurement, the two components should be measured independently. The multimeter can be configured to make the best possible DC measurement using the proper range and integration to reject the AC component. When making the AC measurement, select the appropriate range for just the AC component. You can compute the total AC+DC RMS value with the following formula:

$$\text{True RMS}_{AC+DC} = \text{SQRT} (AC^2 + DC^2)$$

Agilent's new 34410A and 34411A use a DC blocking capacitor when they make an AC voltage measurement. The AC measurement is made using a digital technique that provides faster settling times and can handle higher crest factors that are common when you measure pulse trains. When you measure pulses, make sure they do not contain frequencies greater than the multimeter's bandwidth. The 34410A and 34411A can measure AC signals up to 300 kHz. If the AC component has most of its frequency content below 8 kHz, the 34410A or 34411A can accurately measure both the DC and AC component using the DC function with peak detect. For higher-frequency signals, you can measure the AC component separately and use the formula to compute the AC+DC measurement.
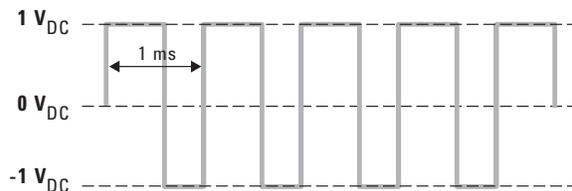

Figure 3

An asymmetric square wave waveform with a duty cycle that is not equal to 50%. A multimeter can be used to measure both the AC and the DC component.
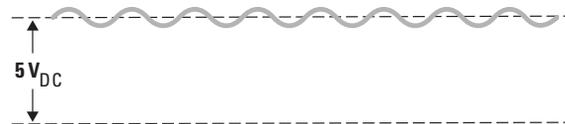

Figure 4

The output of a DC power supply has some ripple AC noise. The power supply output can be characterized by measuring the AC and DC component.
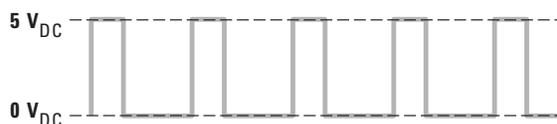

Figure 5

A pulse train has both a DC and an AC component. When you measure pulses, make sure you do not exceed the multimeter's bandwidth.

Hint

**Measuring
low-frequency
AC signals
with a digital
multimeter**

Most modern multimeters
can measure AC voltages with
frequencies as low as 20 Hz.
Some applications require
measuring signals with even
lower frequencies. To make
these measurements you will
need to select an appropriate
multimeter and configure it
properly. A few examples:

**Agilent's 34410A and 34411A
multimeters** use a digital sampling
method to make true RMS meas-
urements that are specified to
measure down to 3 Hz. Using a
digital method improves settling
time to 2.5 s for the slow filter.
To make the best measurement,
you need to take a few precautions:

1. It is important to set the
correct AC filter. The filter
smoothes the output of the
true RMS converter. For
frequencies less than 20 Hz,
the correct setting is LOW.
At the LOW filter setting,
a 2.5-second delay is inserted
to ensure the multimeter
is settled. Use the
VOLTage:AC:BANDwidth MIN
command to set the low filter.

2. If you know the maximum
level for the signal you are
measuring, setting a manual
range will help speed meas-
urement time. The longer
settling times required for
each low-frequency measure-
ment can slow the auto-
ranging feature significantly.
We recommend you set a
manual range.

3. The 34401A uses a DC block-
ing capacitor to prevent DC
signals from being measured
by the AC RMS converter. This
allows the multimeter to use
the best range for measuring
the AC component. When
measuring a source with high
output impedance, ample time
is necessary to ensure the
blocking capacitor is settled.
Settling time is not affected
by the frequency of the AC
signal, but rather by any
change in the DC signal.

The Agilent 3458A has three methods for measuring AC RMS voltages; its synchronously sub-sampled mode can measure down to 1 Hz. To configure the multimeter to measure low frequencies:

1. Select the synchronously sub-sampled mode: SETACV: SYNC

2. When you are using synchronous sub-sampling, the input signal is DC-coupled for both the ACV and ACDCV function. In the ACV function, the DC components are mathematically subtracted from the reading. This is important to consider since the combined AC and DC voltage levels may cause an overload condition, even though the AC voltage alone normally would not.

3. Selecting the proper range will speed measurements, since the auto-range feature can cause delays when you measure low-frequency signals.

4. In order to sample the waveform, the multimeter needs to determine the period of the signal. Use the ACBAND command to determine time-

out values. If you don't use the ACBAND command, the multimeter could timeout before the waveform repeats.

5. The synchronously sub-sampled mode uses the LEVEL trigger to sync to the signal. It is possible for noise on the input to produce false level triggers and inaccurate readings. It is important to select a level that will provide a reliable trigger source. For example, avoid the peaks of a sinewave since the signal is changing slowly and noise can easily cause false triggers.

6. For accurate readings, ensure that your nearby environment is electrically "quiet," and use shielded test leads. Enabling level filtering, LFILTER ON, reduces sensitivity to this noise.

You configure the 34401A the same way you configure the 34410A and 34411A. The 34401A uses an analog circuit with a DC blocking capacitor to convert the RMS voltage. The 34401A is specified to measure down to 3 Hz. To make the best possible measurements, select the low frequency filter, use manual ranging, and verify that any DC offset is stable. When you use the slow filter a 7-second delay is inserted to ensure the multimeter is settled.

Hint 5

Selecting transducers for making temperature measurements with a digital multimeter

Four types of transducers are commonly used for making temperature measurements with a digital multimeter: resistance temperature detectors (RTDs), thermistors, IC sensors and thermocouples. Each type has advantages and disadvantages.

Use thermistors for better sensitivity

Thermistors consist of semiconductor materials and provide excellent sensitivity, but their temperature range is limited, commonly from -80°C to 150°C. Thermistors have highly non-linear temperature-resistance relationships; therefore, their conversion algorithms are complex. Agilent multimeters use the standard Hart-Steinhart approximation to provide accurate conversions, with a typical resolution of .08°C.

Use RTDs for more accuracy

Resistance temperature detectors (RTDs) provide very accurate, highly linear relationships between resistance and temperature, over a range of roughly -200 to 500°C. Modern multimeters such as the Agilent 34410A provide measurement for the IEC751 standard RTD, which has a sensitivity of .0385 ohm/ohm/°C.

IC temperature sensors produce a linear voltage per degree C

Many vendors provide probes that produce a voltage proportional to temperature in degrees C or F. The probes typically use an IC temperature sensor such as the National Semiconductor LM135 series. A temperature IC can cover temperatures from -50°C to +150°C. You can easily compute the temperature from the probe output shown on the multimeter display. For example, 270 mV is 27°C.

Thermocouples offer extreme temperature measurements

Thermocouples can measure the broadest range of temperature, from -210°C to 1100°C, and their rugged construction makes them ideal for harsh environments. Unlike other temperature sensors, thermocouples make a relative measurement and require a reference junction to make an absolute measurement. For most applications it is not practical to add an external reference junction. We recommend using the Agilent 34970A data logger with a 34901A 20-channel multiplexer with built-in reference junction. The 34970A also has built-in temperature algorithms for common thermocouples.

Summary

For monitoring a single temperature, a thermistor and a multimeter like the 34410A make a simple low-cost solution. For more accurate temperature readings, use an RTD. When monitoring many temperatures or high temperatures, a dedicated data logger is the best choice.

	RTD	Thermistor	IC sensor	Thermocouple
Measurement type	Absolute	Absolute	Absolute	Relative
Advantage	• Most stable • Most accurate • More linear than thermocouples	• High sensitivity • Low thermal initiative (fast) • 2-wire measurement	• Most linear • Highest output • Inexpensive	• Wide temperature range • Rugged • Self-powered • Inexpensive • Wide variety of physical forms
Disadvantage	• Expensive • High thermal initiative (slow) • Requires current source • Small resistance changes • 4-wire measurement • Self-heating	• Nonlinear • Limited temperature range • Fragile • Requires current source • Self-heating • Should use 4-wire measurement for high temperatures	• Limited to 250°C • Requires power supply • High thermal initiative (slow) • Self heating • Limited configurations	• Nonlinear • Low output voltage • High thermal initiative (slow) • Requires reference • Connection, oxidation • Least sensitive

Table 1: *Comparison of common types of temperature transducers*

6 Hint

Making a group of measurements with a multimeter

Multimeters often use a two-level triggering system; to make a reading, both sets of triggering conditions have to be satisfied. Figure 6 illustrates the two-level triggering model used in the 34401A multimeter. Typically the number of samples and number of triggers is set to one when a trigger is received a single reading is taken. The number of samples can be increased to take N samples when a single trigger is received. If the number of samples is left equal to one and the trigger count is increased to N, then a trigger would be required for each reading. In both cases, a trigger delay is inserted between each reading.

Trigger delay by default is configured by the multimeter to allow the measurement to settle, and it varies depending on range and function. The trigger delay can be set manually. It is important to note that the delay is implemented in software and will have some time variation. In addition, measurement time tends to vary, so it is difficult to use this scheme to sample a signal on a regular interval. Figure 7 demonstrates a series of measurements taken using a trigger delay.

A second trigger model is shown in Figure 8. This model is used in the 34410A, 34411A and 3458A. It allows the trigger delay and the time between samples to be set independently. In addition, the sample loop (n readings) is designed to make readings quickly and with minimal variation in time. Most of the sample loop is implemented in hardwarewith a minimum of firmware to insure consistent timing. The 34410A, 34411A and 3458A can be configured to take sample readings as fast as possible or using a timer.

To configure a burst of measurements, set the trigger delay to allow settling after the trigger and before the first reading. Use the timer to set a precise interval between readings. The 34410A and 34411A have a front-panel data logger feature that simplifies configuring a burst measurement.
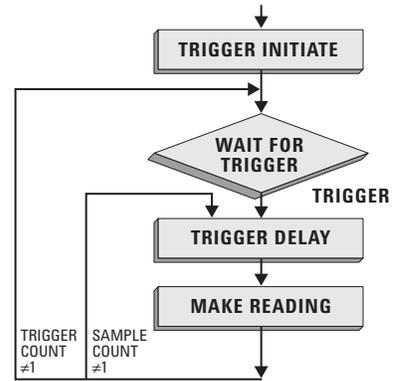

Figure 6:

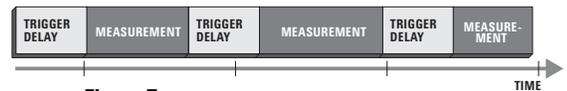*A simple trigger scheme that uses a trigger delay to space readings over time*

Figure 7:

Measurements taken using trigger delay, where each measurement takes a different amount of time to complete. This model is not ideal for sampling a signal because the time between the start of each measurement varies.
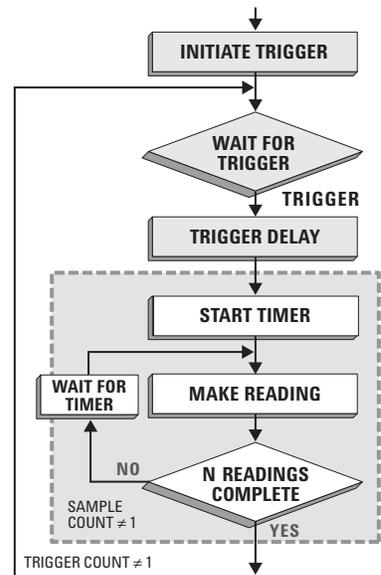

Figure 8:

Trigger model used in the 34410A and 34411A. Allows for precise timing between readings

7 Hint

Detecting Peaks
with a Multimeter

Multimeters are well suited for sampling low-frequency signals using the DC function. Typically, the bandwidth will be limited to 8 kHz or less. Traditionally, an analog peak detect circuit was used to capture and hold the peak voltage until an A/D circuit could measure the voltage. This technique provides high bandwidth and is still used to capture peaks of very short duration. It also is used in multi-channel systems where a single A/D is used in conjunction with a peak detector on each channel. A more common technique is to sample a signal very quickly and store the largest and the smallest value.

For many applications, the energy contained in noise spikes displayed on an oscilloscope display is of little consequence. Often, the noise is created by EMI and can mask the signal of interest—for example automobile engines generate a tremendous amount of EMI. Physical measurements—such as those made by temperature or oil sensors—typically change fairly slowly. You can reject high-frequency noise using a filter and a slower A/D. It is not necessary to use a high-speed A/D to sample the output of a filter.

A multimeter is often a very appropriate tool for determining and measuring peaks. A multimeter provides signal conditioning (gain, attenuation, and low pass filtering) along with a reasonable sampling rate (1 KSa/s to 50 KSa/s). Most multimeters have a built-in math feature that you can use to determine the maximum and minimum value. To get the highest reading rate, you may need to post-process the data, as the math function may slow the reading rate. Other ways to increase reading speed include selecting a small aperture, turning off autozero, and turning off the display.

Characterizing a signal and determining the peaks is such a common task that Agilent's new 34410A and 34411A multimeters include a peak detect feature. When you monitor a DC signal, you can use the second display to show the maximum peak, minimum peak and the peak-to-peak value. The peak detect feature is always sampling at 50 KSa/s, regardless of the multimeter's aperture setting, and math is not required. Figure 9 shows that the peak reading will normally be updated for each reading.
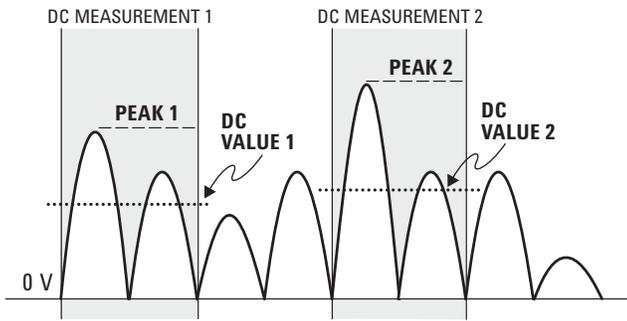
Figure 9:

A peak measurement is made with each measurement.

The alternative to making a single reading is to set up a group of readings that will return a single peak measurement result for the group of DC readings as shown in Figure 10.
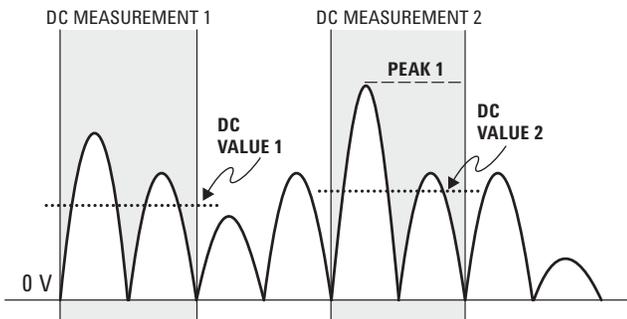

Figure 10:

A single peak measurement will be returned for a set of readings.

A third alternative is to change the multimeter's aperture and make one long reading. The third method is illustrated in Figure 11. A single peak measurement will be returned for the longer measurement.

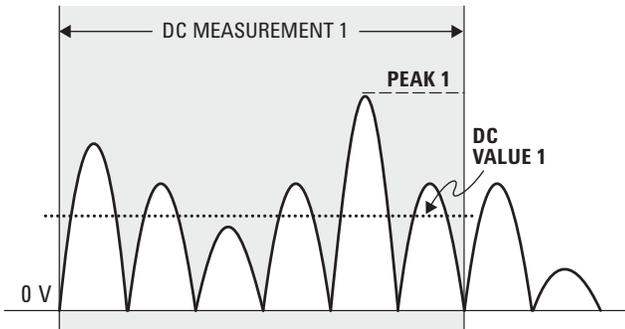
Figure 11:

A single peak will be returned for a measurement, but the measurement can be made over a long period.

The 34410A and 34411A peak detect will sample the signal every 20 µsec. The peak will be held until the next trigger. You can change the aperture to hold a peak value for a longer period of time. Each peak measurement will provide peak to peak, peak maximum and peak minimum.

8 Hint

Using accessories to get the most from your multimeter

Easier probing

Often, you need two hands and both eyes to probe a PC board; looking up at the multimeter display may cause the probes to slip. Some multimeters, like the 34401A, 34410A and 34411A, offer a reading Hold feature that locks in a valid reading. Freezing the reading allows you to concentrate completely on probing. Using the Agilent 34133A precision electronic test leads can make the job even easier. The test leads are small, lightweight and feature Agilent's patented browser, which uses a crown point pogo pin. The spring-loaded tip helps absorb those small movements and the crown point digs into solder.

High-voltage and high-current probing

High-voltage probes enable you to measure high voltages safely with a multimeter. The Agilent 34136A high voltage probe is designed to be used with the 34401A, 34410A, and 34411A in the fixed input impedance mode (input resistance of 10 MΩ). The probe is a 1000:1 divider that extends a voltmeter's measurement capability to 40 kV DC.

If you want to measure DC and low-frequency AC current (to 30 A, and 15 A continuous) try the Agilent 34330A current shunt, (above) a precision 0.001-ohm resistor housed in a plastic case surrounded by epoxy. Output is 1mV per A of current passing through the shunt. The current to be measured is connected to the shunt via binding posts. Simply inset the wire and tighten the binding post for easy connections.

Keep your probes and manual with the instrument

Ever wasted time hunting for your probes or user guide? You'll always know right where they are if you store them in an instrument "backpack." Agilent offers two sizes of nylon pouches to fit on top of our most popular multimeters. The 34162A pouch is specially designed to fit on shorter instruments, such as the 34410A and 34411A mutimeters. The 34161A pouch fits 34401A and 34420A mulitmeters.

### Making four-wire ohm measurements? Order additional probes.

If you are making four-wire ohm measurements, you need a second set of leads. 34138A leads are identical to the ones that ship with the 34410A and 34411A. They include some fine-tip probes and mini grabbers. Agilent's 34132A deluxe test leads kit includes two test leads, spring-loaded retractable hook leads, alligator clips, needle point and a reusable nylon case.

Create a neat wiring harness and minimize offsets errors

The Agilent 34171A DMM input terminal connector block is a set of two connectors that provides a convenient and reliable method to connect wires to all five input terminals. Terminals are made of low-thermal copper alloys to minimize thermally induced voltages caused by dissimilar metals. It is compatible with the 34401A, 34410A, and 34411A. For minimum thermal offset voltages, use unplated copper wire of the same gauge for all connections.

Introducing the next generation of industry-standard multimeters
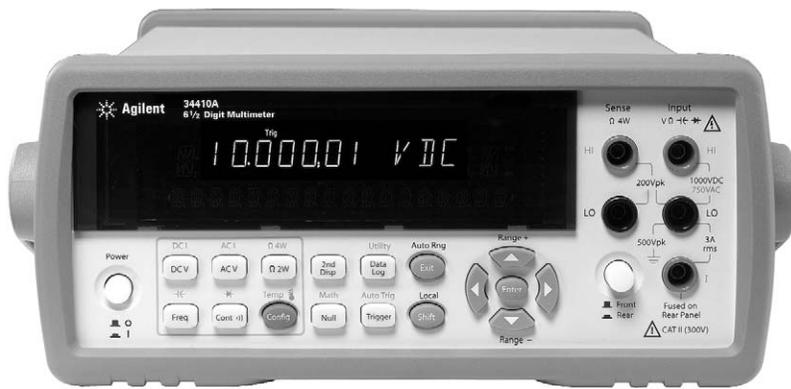
Agilent 34410A and 34411A digital multimeters offer improved speed, more performance, additional memory and more PC connectivity options than the 34401A.

34401A $6\frac{1}{2}$ digit DMM	34410A high-performance $6\frac{1}{2}$ digit DMM	34411A enhanced performance $6\frac{1}{2}$ digit DMM
		All of the 34410A features, plus:
1,000 rds/sec @ $4\frac{1}{2}$ digits	10,000 rds/sec continuous @ $5\frac{1}{2}$ digits	50,000 rds/sec @ $4\frac{1}{2}$ digits
512 rds memory	50,000 rds non-volatile memory	1M reading memory
DC accuracy 0.0035%	DC accuracy 0.0030%	Analog level triggering
GPIB and RS-232 standard	LAN, USB and GPIB all standard	Pre- and post-triggering
	Capacitance and temperature	
	Data logger capability	
	Dual display	

Get even more accuracy and performance than you've come to expect

The Agilent 34410A and 34411A $6\frac{1}{2}$ digit DMMs—the latest generation of multimeters from Agilent —build on the phenomenal success of the industry-standard Agilent 34401A. These new meters offer improved accuracy, expanded measurement capability, dramatically improved measurement speed and throughput, and modern computer interfaces including LAN and USB—so you can make fast, accurate measurements and transfer them to your PC with ease. The dual display offers dual measurement capabilities and makes it easy for you to set up and configure the DMM. We've made improvements in every facet of the 34401A to make the best even better, whether you use it on the bench or in a system.

Dramatic speed improvements

Whether you need raw reading speed or fast system throughput — or both—the 34410A sets a new benchmark in performance. Using new A/D technology, the 34410A achieves an impressive 10,000 readings a second at $5\frac{1}{2}$ digits, and can stream readings to your computer at this same speed. Triggering is fast and precise, with both trigger latency and trigger jitter less than 1 µs, while bus query response is less than 500 µs. ACV measurements are faster as well, thanks to a digital measurement technique that further improves accuracy at high and low frequencies. For even greater reading speeds, select the 34411A, which achieves 50,000 readings/second at $4\frac{1}{2}$ digits.

The performance you need

The 34410A and 34411A offer temperature and capacitance capabilities, in addition to those measurements you have come to expect, such as DCV, ACV, DCI, ACI, 2-wire and 4-wire resistance, frequency, period, continuity and diode test. You also get offset-compensated ohms, allowing you to accurately measure resistance in the presence of voltages. Measurement ranges have been expanded as well; for example, DC and AC current ranges now go down to 100 µA, resulting in 100 pA resolution. Real-time math and statistics are included, and a peak detect capability allows you to capture peaks as short as 20 µs.

Make unattended measurements with the data logger function

A front-panel data logger function allows you to set the meter up to make unattended, paced measurements over a fixed time or number of events, then pull up the results later for review or transfer to a computer for analysis. Set the meter up to take measurements every 10 seconds for an hour, go have lunch, and check the results upon your return. The contextual front-panel sequences make setup and read back a breeze.

Specifications: 34410A / 34411A digital multimeters, 6½ digits

Function	Range	Frequency, test current or burden voltage	1-year Tcal ± 5°C
DC voltage	100.0000 mV		0.0050 + 0.0035
	1.000000 V		0.0035 + 0.0007
	10.00000 V		0.0030 + 0.0005
	10.00000 V		0.0030 + 0.0005
	100.0000 V		0.0040 + 0.0006
	1000.000 V		0.0040 + 0.0006
True RMS AC voltage		3 Hz – 5 Hz	0.50 + 0.03
		5 Hz – 10 Hz	0.10 + 0.03
	100.0000 mV	10 Hz – 20 kHz	0.06 + 0.03
	to 750.000	20 kHz – 50 kHz	0.10 + 0.05
		50 kHz – 100 kHz	0.40 + 0.08
		100 kHz – 300 kHz	1.20 + 0.5
Resistance	100.0000 Ω	1 mA	0.010 + 0.004
	1.000000 kΩ	1 mA	0.010 + 0.001
	10.00000 kΩ	100 µA	0.010 + 0.001
	100.0000 kΩ	10 µA	0.010 + 0.001
	1.000000 MΩ	5 µA	0.012 + 0.001
	10.00000 MΩ	500 nA	0.040 + 0.001
	100.0000 MΩ	500 nA – 10 M	0.800 + 0.001
	1.000000 GΩ	500 nA – 10 M	8.000 + 0.001

DC current	100 µA to 3 A ranges
AC current	100 µA to 3 A ranges
Frequency (period)	3 Hz (0.333s) to 300 kHz (3.33 s)
Capacitance	1 nF to 10 µF Range
Temperature	RTD: -220 to 600°C
	Thermistor: -80 to 150°C
Continuity	1000 Ω range, threshold 10 Ω fixed
Diode test	1 V range, 1mA test current
Math functions statistics	Null per range, min/max/avg, dBm,dB, limit test
Data logger	Nonvolatile memory : 50,000 readings
	Volatile memory : 34410A, 50,000 readings
	34411A, 1,000,000 readings
	Sample timer, 0 to 3600 sec, <100 ns jitter
Interfaces	LAN, USB, and GPIB (designed to be LXI class-C compliant)
Maximum input	DC /AC voltage : 1000 Vdc / 750 Vrms (1100Vpk)
	DC and AC current : 3 A, from <250 V fused
Shock and vibration	meets MIL-T-28800E, Type III, Class 5 (sine only)
Power	100/120/220/240 V, 45-66 Hz, 360-440 Hz
	25 VA peak (16 W average)
Net weight	3.72 kg (8.2 lbs)
Warranty	1 year

34401A digital multimeter, 6½ digit

Thousand of engineers worldwide count on the Agilent 34401A for fast, dependable results, knowing the last measurement of the day will be as accurate as the first: 24-hour accuracy is 0.0015% for DC volts and 0.06% for AC volts. One or two button presses give you a wide array of functions, from DC volts to frequency to dB and dBm. Advanced tests include limit checks, min/max/avg read-outs and dc voltage ratios.

3458A digital multimeters, 8½ digit

When your tests demand speed and accuracy without compromise, the Agilent 3458A offers rates up to 100,000 readings, 110 auto-ranges and more than 340 setup changes per second. If precision is the priority, select 8½ digit resolution with 0.1 ppm transfer accuracy. Twenty four hour accuracy is 0.6 ppm for mid-band ac volts. You can also use the extensive set of math and filtering functions to improve your measurement accuracy.

34420A nanovoltmeter, 7½ digit

The Agilent 34420A nanovolt/ micro-ohm meter is optimized for precision low level measure-ments, with 7½ digit resolution and 1.3 nVrms/8 nVpk-pk noise performance. Two input channels let you make voltage measurements independently or mathematically combine them for difference and ratio measurements. Direct SPRT, RTD, thermistor and thermocouple measurements let you track a wide range of temperature sensors.

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