Digital Multimeter Operation

The Agilent Technologies 34405A, 5½ Digital Multimeter (Multimeter)

The Agilent Technologies 34405A Multimeter is a digital measurement device capable of making the following basic measurements:

1. DC Voltage
2. AC Voltage
3. DC Current
4. AC Current
5. Resistance
6. Capacitance
7. Frequency
8. Continuity tests
9. Diode Checks
10. Temperature

This Multimeter provides automatic polarity detection, overrange indication, and protection from accidental overloads. The basic specifications of the Agilent Technologies 34405A Multimeter are summarized in Table 1.

Table 1. Basic Specifications of the Agilent Technologies 34405A Multimeter

DC Volts Measurement Specifications			
Ranges	Resolution	Accuracy	Input Impedance
100.000 mV	1 μV	±(0.025% of reading + 0.008% of range)	10 MΩ ± 2%
1.00000V	0.01 mV	±(0.025% of reading + 0.006% of range)	
10.0000 V	0.1 mV	±(0.025% of reading + 0.005% of range)	
100.000 V	1 mV		
1000.00 V	10 mV		

AC Volts Measurement Specifications (True RMS)		
Ranges	Resolution	Accuracy
100.000 mV	1 μV	±(1.0% of reading + 0.1% of range) @ 20-45 Hz
		±(0.2% of reading + 0.1% of range) @ 45 Hz-10 kHz
		±(1.5% of reading + 0.3% of range) @ 10 kHz-30kHz
		±(5.0% of reading + 0.3% of range) @ 30 kHz-100 kHz
1.00000 V	10 μV to 10 mV	±(1.0% of reading + 0.1% of range) @ 20- 45 Hz
10.0000 V		±(0.2% of reading + 0.1% of range) @ 45 Hz-10 kHz
100.000 V		±(1.0% of reading + 0.1% of range) @ 10 kHz-30kHz
750.00 V		±(3.0% of reading + 0.2% of range) @ 30 kHz-100 kHz

Direct Current Measurement Specifications			
Ranges	Resolution	Accuracy	Loading Error
10.0000 mA	0.1 μA	±(0.05% of reading + 0.015% of range)	< 0.2 V
100.000 mA	1 μA	±(0.05% of reading + 0.015% of range)	< 0.2 V
1.00000 A	10 μA	±(0.20% of reading + 0.007% of range)	< 0.5 V
10.0000 A	100 μA	±(0.25% of reading + 0.007% of range)	< 0.6 V

Alternating Current Measurement Specifications (True RMS)		
Ranges	Resolution	Accuracy (differences depend on frequency)
10.0000 mA 100.000 mA 1.00000 A 10.0000 A	0.1 μA 1 μA 10 μA 100 μA	±(1.5% of reading + 0.1% of range) @ 20 Hz- 45 Hz
		±(0.5% of reading + 0.1% of range) @ 45 Hz- 1 kHz
		±(2.0% of reading + 0.2% of range) @ 1 kHz- 10 kHz
		±(2.0% of reading + 0.2% of range) @ 1 kHz- 10 kHz

Resistance Measurement Specifications			
Ranges	Resolution	Accuracy	Max Test Current
100.000 Ω	0.001 Ω	±(0.05% of reading + 0.008% of range)	1.0 mA
1.00000 kΩ	0.01 Ω	±(0.05% of reading + 0.005% of range)	0.83 mA
10.0000 kΩ	0.1 Ω	±(0.05% of reading + 0.006% of range)	100 μA
100.000 kΩ	1 Ω	±(0.05% of reading + 0.007% of range)	10.0 μA
1.00000 MΩ	10 Ω	±(0.06% of reading + 0.007% of range)	900 nA
10.0000 MΩ	100 Ω	±(0.25% of reading + 0.005% of range)	205 nA
100.000 MΩ	1 kΩ	±(2.00% of reading + 0.005% of range)	205 nA

Frequency (The Ranges refer to the voltage ranges of the signal whose frequency we wish to measure.)		
Ranges	Freq. Range	Accuracy
100.000 mV 1.00000 V 10.0000 V 100.000 V 750 V	< 2 Hz	±(0.18% of reading + 0.003% of range)
	< 20 Hz	±(0.04% of reading + 0.003% of range)
	20 Hz – 100 kHz	±(0.02% of reading + 0.003% of range)
	100 kHz ~ 300 kHz	±(0.02% of reading + 0.003% of range)

Capacitance Measurement Specifications			
Range	Resolution	Accuracy	Test Current
1.000 nF	1 pF	±(2.0% of reading + 0.8% of range)	0.75 μA
10.00 nF	10 pF	±(1.0% of reading + 0.5% of range)	0.75 μA
100.0 nF	100 pF	±(1.0% of reading + 0.5% of range)	8.3 μA
1.000 μF	1 nF	±(1.0% of reading + 0.5% of range)	83 μA
10.00 μF	10 nF	±(1.0% of reading + 0.5% of range)	83 μA
100.0 μF	100 nF	±(1.0% of reading + 0.5% of range)	83 μA
1000 μF	1 μF	±(1.0% of reading + 0.5% of range)	0.83 mA
10,000 μF	10 μF	±(2.0% of reading + 0.5% of range)	0.83 mA

Digital Multimeter Operation

Figure 1 shows the front panel of the Agilent Technologies 34405A Multimeter, illustrating its display, input connections, and control switches. We provide a brief description of each item below.

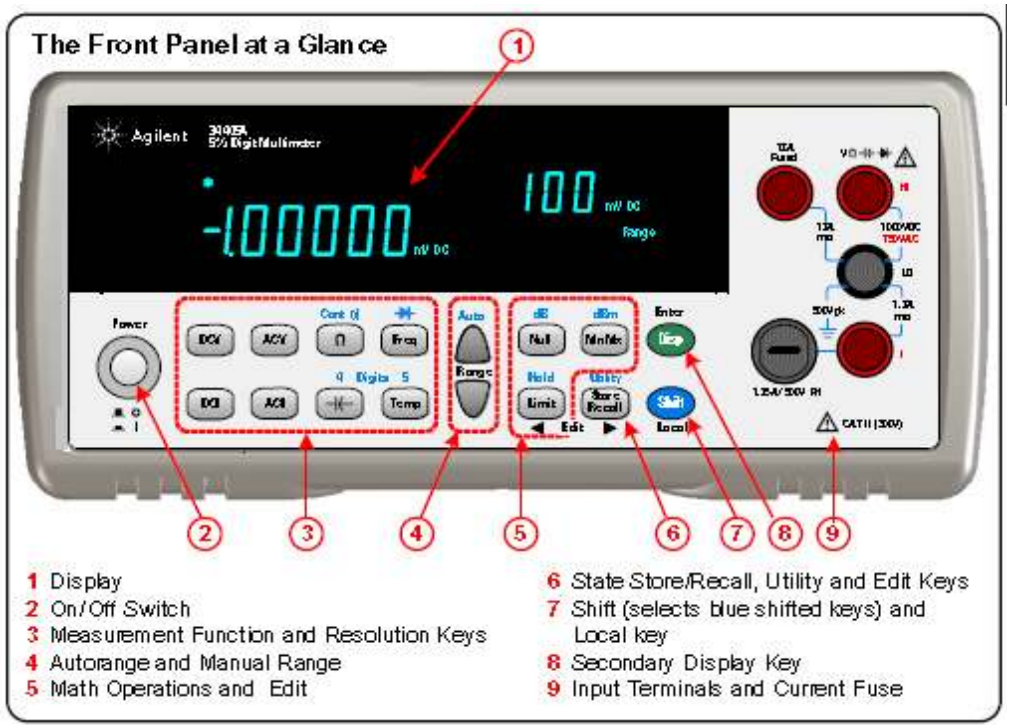


Figure 1. The Front Panel of the Agilent Technologies 34405A Multimeter

1. Display. The overall features of the Display are indicated in Figure 2. The Primary Measurements section shows the numerical results of the measurement. The Primary Measurement Function and Units indicates what function the Multimeter is measuring and the appropriate units. The Secondary Display shows the range and additional measurement values. The Secondary Measurement Function and Units also indicates what function the Multimeter is measuring in the secondary mode and the appropriate units. There are System Annunciators and Range and Shift Annunciators.

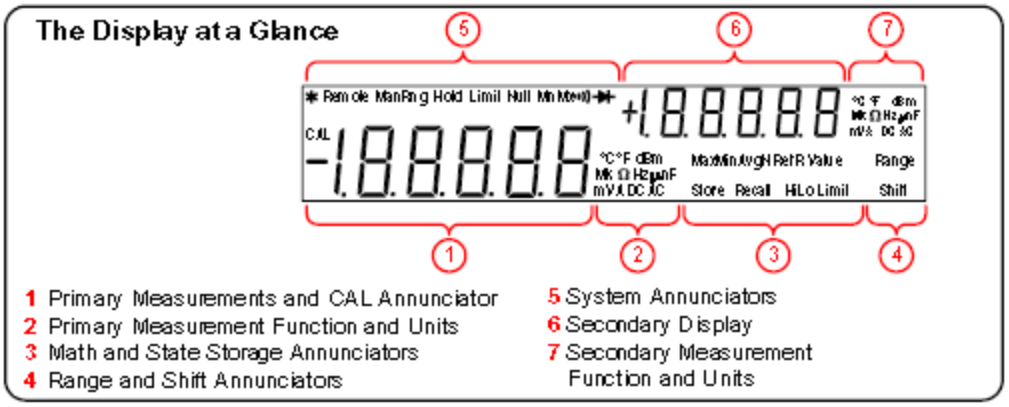


Figure 2. The Display of the Agilent Technologies 34405A Multimeter

2. On/Off Switch. Powers the Agilent Technologies 34405A Multimeter on or off. Power ON is indicated by the Display.

3. Measurement Functions and Resolution Keys. Push in a button to select among the 10 possibilities (2 of which are selected by using the blue Shift Key). The Resolution is selected between 4½ digits or 5½ digits – also accessed via the Shift Key.

Setting the Resolution

You can select either 4½ or 5½- digit resolution for the DCV, DCI, resistance, ACV, ACI and frequency measurement functions.

- 5½- digit readings have the best accuracy and noise rejection.
- 4½- digit readings provide for faster readings.
- The continuity and diode test functions have a fixed, 4½- digit display.
- Capacitance and temperature have a fixed 3½- digit display.
- Shift and "4" selects 4½- digit mode.
- Shift and "5" selects 5½- digit mode.

4. Autorange and Manual Range Keys. Push to select the highest value of the voltage, current, or resistance to be measured.

Selecting a Range

You can let the multimeter automatically select the range using *autoranging*, or you can select a fixed range using *manual ranging*. Autoranging is convenient because the multimeter automatically selects the appropriate range for sensing and displaying each measurement. However, manual ranging results in better performance, since the multimeter does not have to determine which range to use for each measurement.

- The Down key selects a lower range and disables autoranging.
- The Up key selects a higher range and disables autoranging.
- The Shift and Up key selects autoranging and disables manual ranging.
- The **ManRng** annunciator is on when manual range is enabled.
- Autoranging is selected at power- on and after a remote reset.
- Manual ranging – If the input signal is greater than can be measured on the selected range, the multimeter provides these overload indications: **OL** from the front panel or "\9.9E+37" from the remote interface.
- For frequency measurements, ranging applies to the signal's input voltage, not its frequency.
- The range is fixed for continuity (1 kΩ range) and diode (1 VDC range).
- The multimeter remembers the selected ranging method (auto or manual) and the selected manual range for each measurement function.

5. Math Operations and Edit

Not used in this course

6. State Store/Recall, Utility and Edit Keys

Not used in this course

7. Shift (selects blue shifted keys) and Local key

8. Secondary Display Key – see below

9. Input Terminals and Current Fuse

LO Terminal – For the common (black) test lead. Used for all measurements. This connector is not connected to the power source ground through the instrument and can accept voltages up to 500 V-peak. This feature is very important when checking voltages across devices that have no connections to ground. Otherwise, the Multimeter would short out parts of the circuit. (The oscilloscope will have a ground clip that is truly at a ground reference and special care has to be taken when using it.)
HI Terminal – Input terminal for positive (red) test lead. Used for all measurements EXCEPT for current.
I Terminal – Input connector for positive (red) test lead when instrument is used to measure current values up to 1.2 A.
12 A Fused Terminal. Input connector for positive (red) test lead when instrument is used to measure high current (over 1.2 A but less than 12 A).

Taking Measurements

This section explains how to take the following measurements:

- AC or DC voltage
- AC or DC current
- Resistance
- Capacitance
- Frequency
- Check diodes

Figure 3 illustrates how the test leads should be connected to the input terminals for the various measurements.

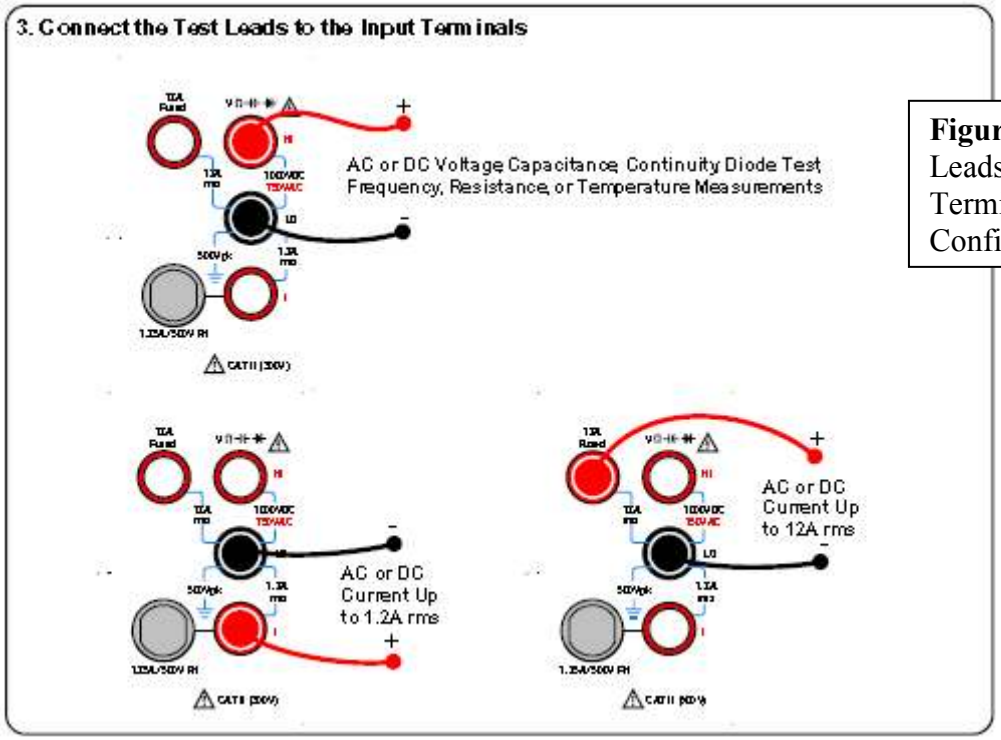


Figure 3. Test Leads and Input Terminal Configurations

Preparations for Measurement

1. Be sure that the Agilent Technologies 34405A Multimeter is connected to a specified power source. Turn ON the power

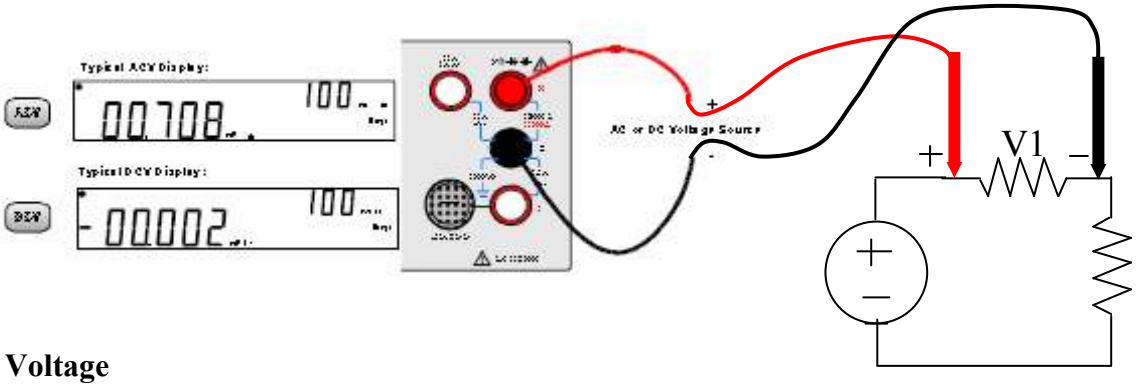
3. Be sure the red test lead is in the proper input terminal for the measurement to be made. *This preparation step is crucial when switching from measuring current to measuring voltage. If the test lead is left in the terminal for current when trying to measure voltage (such as across a power supply), then the Multimeter can act as a short circuit and could draw too much current, blowing a fuse.*

Measuring AC or DC Voltage

1. Connect the black test lead to the black LO jack.
2. Connect the red test lead to the red HI jack.
3. Press the DCV or ACV key.

NOTE. Voltage readings are taken in parallel with the component or device being measured.

4. Connect the test leads, and read the displayed value.



Voltage

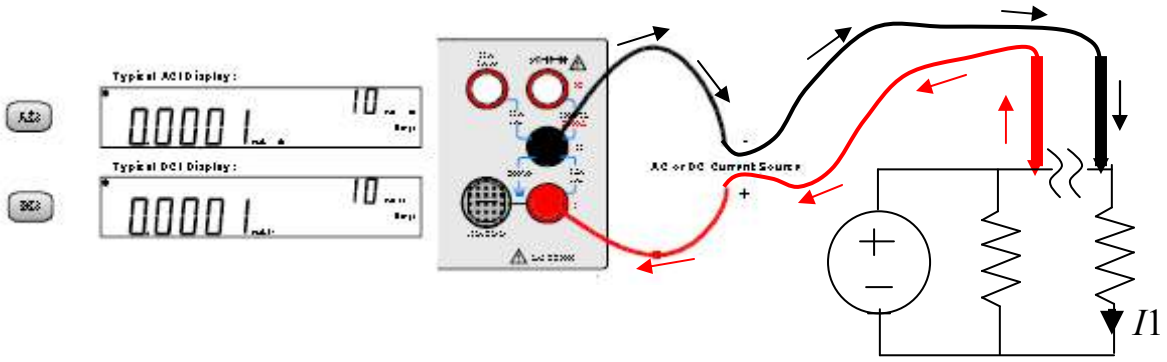
(The component remains in the circuit and the Multimeter is in **parallel** with the component.) For the test setup shown, the Multimeter measures V1. If V1 is positive, then the Multimeter gives a positive result. The Multimeter records a positive voltage if the HI terminal is at a higher potential than the LO terminal.

Measuring AC or DC Current

1. Connect the black test lead to the black LO terminal.
2. For current up to 1.2 A, connect the red test lead to the red 1.2A terminal. For current between 1.2 A and 12 A, connect the red test lead to the red 12A FUSED terminal.
3. Press the DCI or ACI key.

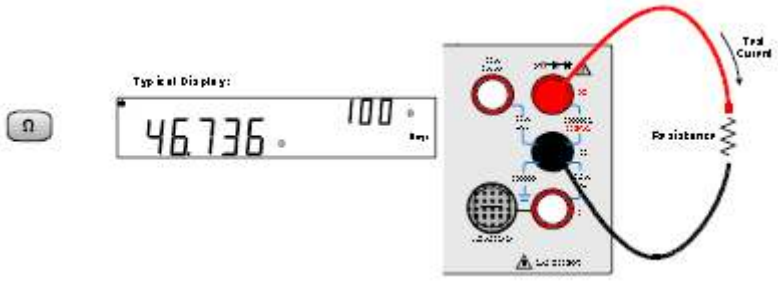
NOTE Current readings are taken in series with the component or device being measured.

4. Connect the test leads, and read the display value.



Current
(The Multimeter must go in **series** with the branch under test so that the circuit must be broken and the ammeter inserted at the break.) For the test setup shown, the Multimeter measures *I*1. If *I*1 is positive, then the Multimeter gives a positive result. The arrows indicate the direction of a positive current through the ammeter.

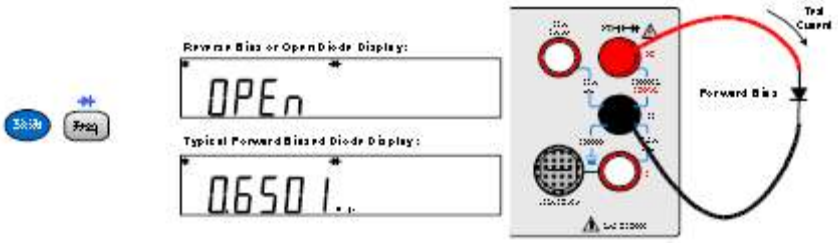
Measuring Resistance
1. Connect the black test lead to the black LO terminal.
2. Connect the red test lead to the red HI terminal.
3. Press the Ω (ohms) function button.
4. Disconnect the component from the circuit in case there are other parallel pathways. The multimeter will produce a current and measure the voltage as a means to determine the resistance. Multiple paths in parallel across the resistor will cause erroneous measurements.
5. Connect the test leads, and read the display value.



Resistance
(The resistor is removed from the circuit.)

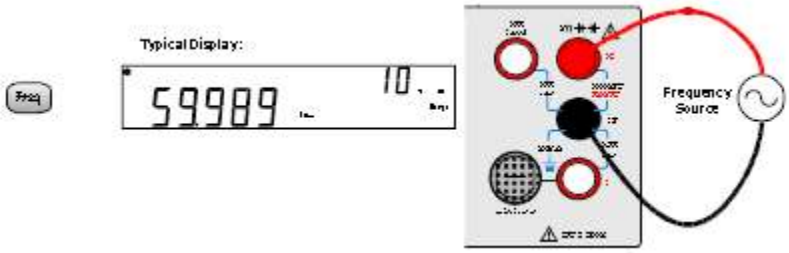
Checking Diodes

1. Connect the black test lead to the black LO terminal.
2. Connect the red test lead to the red HI terminal.
3. Press the blue Shift key and then press the “diode” key.
4. Disconnect the diode from any circuitry before connecting the test leads.
5. Connect the black test lead to the anode and the red test lead to the cathode of the diode.



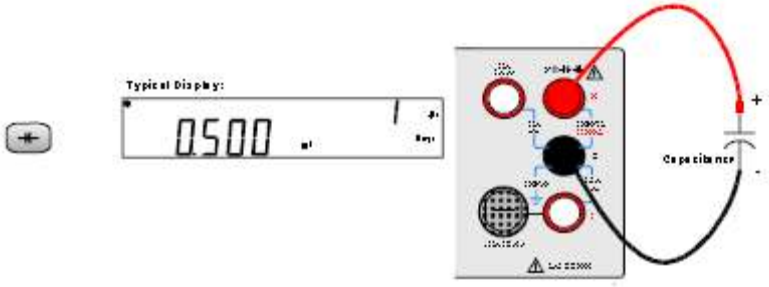
Measuring Frequency

1. Connect the black test lead to the black LO terminal.
2. Connect the red test lead to the red HI terminal.
3. Press the Frequency key.
4. Connect the leads and take the measurement.



Measuring Capacitance

1. Connect the black test lead to the black LO terminal.
2. Connect the red test lead to the red HI terminal.
3. Press the Capacitance key.
4. Disconnect the capacitor from any circuitry before connecting leads.
5. Connect the leads and take the measurement.



Using the Secondary Display

Most measurement functions have predefined range or measurement capabilities that can be displayed in the secondary display. All math operations have predefined operations that are displayed on the secondary display.

Measurement Functions and the Secondary Display

When making measurements, the secondary display allows you to show the measurement range (for most measurement functions) or to select a predefined secondary measurement function. For example, a typical primary display showing DCV and a secondary display showing the DCV range is:

As another example, a typical primary display showing ACV and a secondary display showing the measured frequency of the input signal is:

The secondary display is based on the selected primary measurement function and how many times you press:

The table below shows the secondary display capabilities for all measurement functions.

Repeatedly pressing cycles through the secondary display choices for the present measurement function as shown in the table below. The temperature, continuity and diode functions do not have secondary displays.

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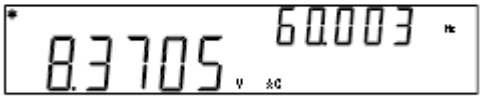
• When a second measurement function is selected, its resolution will match the primary measurement setting and, whenever possible, it will use autorange.

• Enabling any math operation turns off the secondary display for measurements. All math operations offer predefined displays that can be presented on the secondary display.

8. Using the Secondary Display

When making measurements, the secondary display allows you to show the measurement range (for most measurement functions) or to select a predefined secondary measurement function. You may have already noticed the secondary display showing **Auto** for autorange when changing measurement functions:

As another example, a typical primary display showing ACV and a secondary display showing the measured frequency of the input signal is:



The secondary display is based on the selected primary measurement function and how many times you press:

Disp

The table below shows the secondary display capabilities for all measurement functions.

Primary and Secondary Display Functions

Primary Display	Secondary Display		
	Default Secondary Display	Press Disp Once	Press Disp Twice
DCV	DCV Range	ACV	Off
DCI	DCI Range	ACI	Off
Resistance	Resistance Range	Off	Resistance Range
ACV	ACV Range	Frequency	Off
ACI	ACI Range	Frequency	Off
Frequency	AC Voltage Range	ACV	Off
Capacitance	Capacitance Range	Off	Capacitance Range
Temperature	Off	Off	Off
Continuity	Off	Off	Off
Diode Test	Off	Off	Off

RMS Measurements

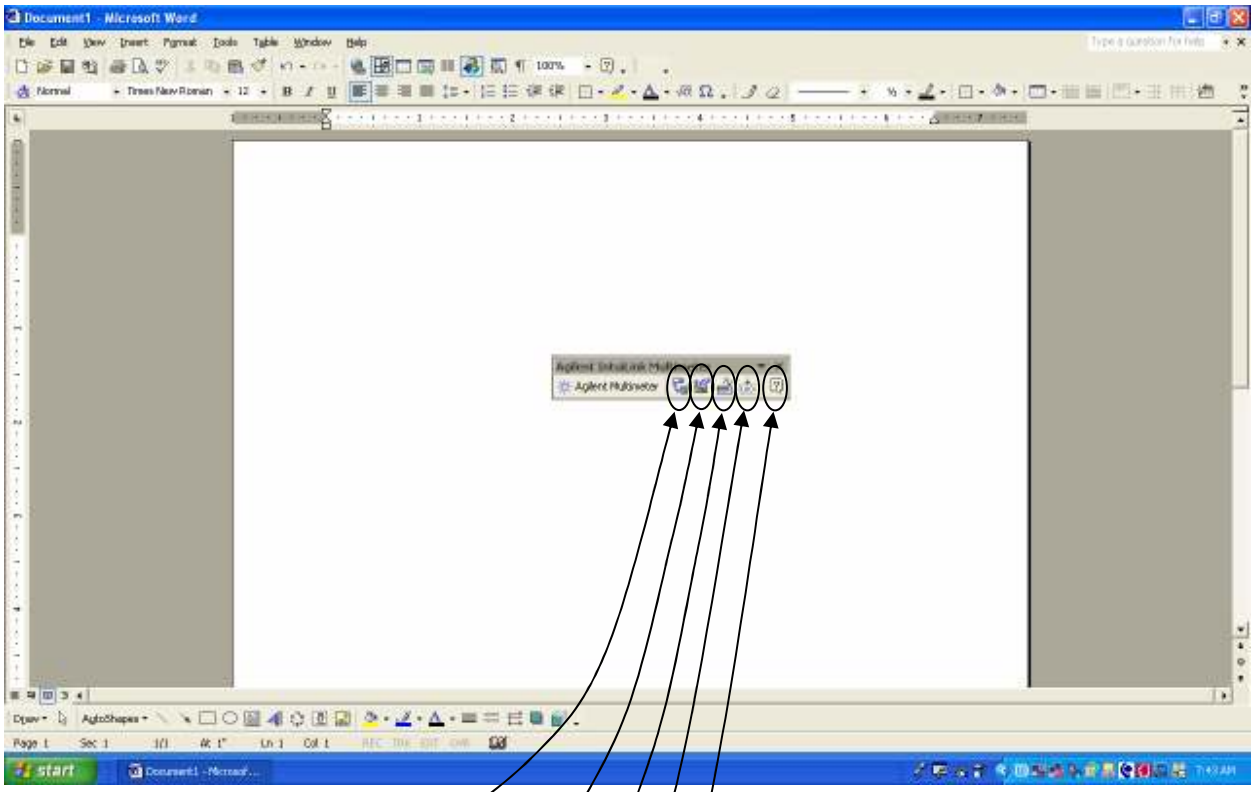
Mathematically, the root-mean-square (RMS) value is defined as the square-**R**oot of the **M**ean (average) value of the **S**quare of a signal, as indicated by the following equation:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt}$$

In physical terms, the RMS value of a periodic signal (with a period of *T*) is the equivalent DC value which would cause the same power dissipation. That is, an AC voltage source with an RMS value of 10 volts connected to a resistor R would generate the same average power as a 10-volt DC source.

Connecting the PC to the Agilent Technologies 34405A Multimeter

1. Open Microsoft Word (or Excel).
2. Double click the shortcut labeled "Word IntuiLink for Multimeters Toolbar Addin" (or "Excel IntuiLink for Multimeters Toolbar Addin").
3. If a window opens that gives a warning about the use of ActiveX controls, go ahead and proceed anyway.
4. You should now see a window that looks something like the following figure for a Word document. You should see a new toolbar with five icons for various operations.



Connect to Multimeter

Save/Load Multimeter Settings

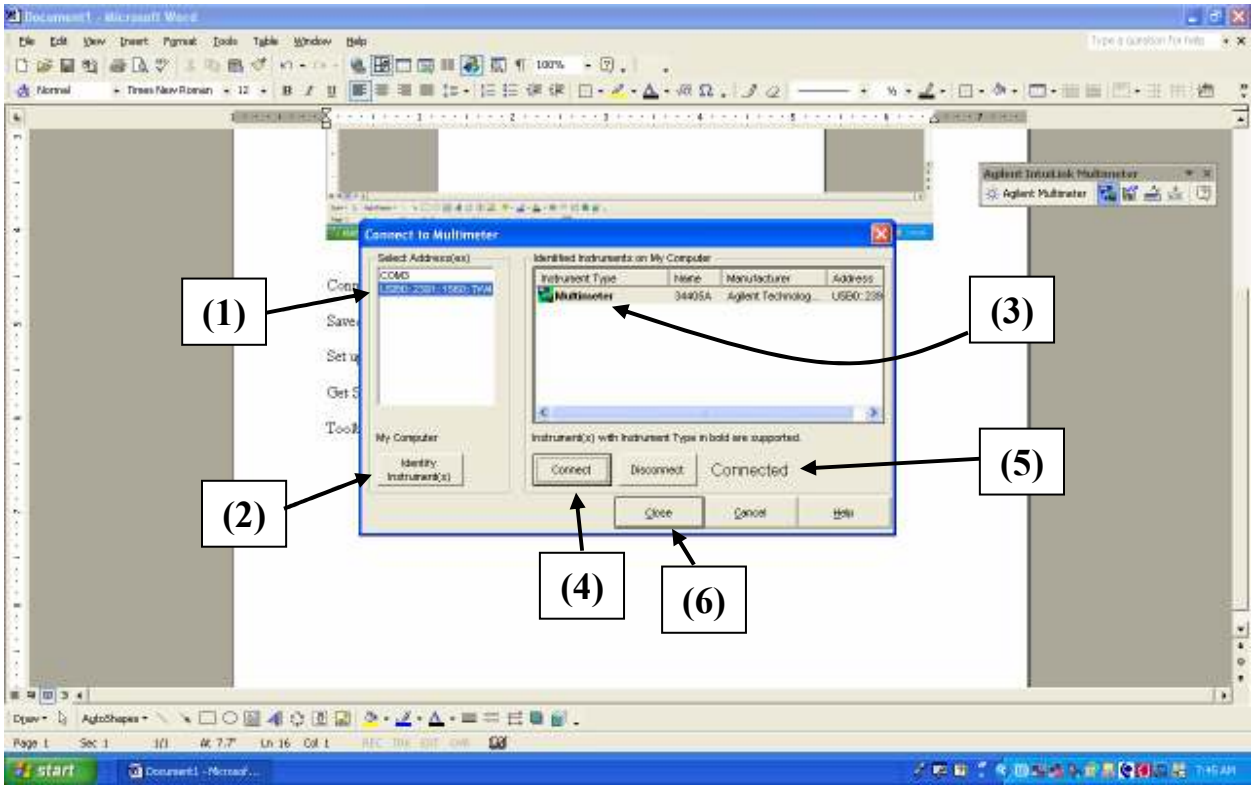
Set up Multimeter

Get Single Reading

Toolbar Help

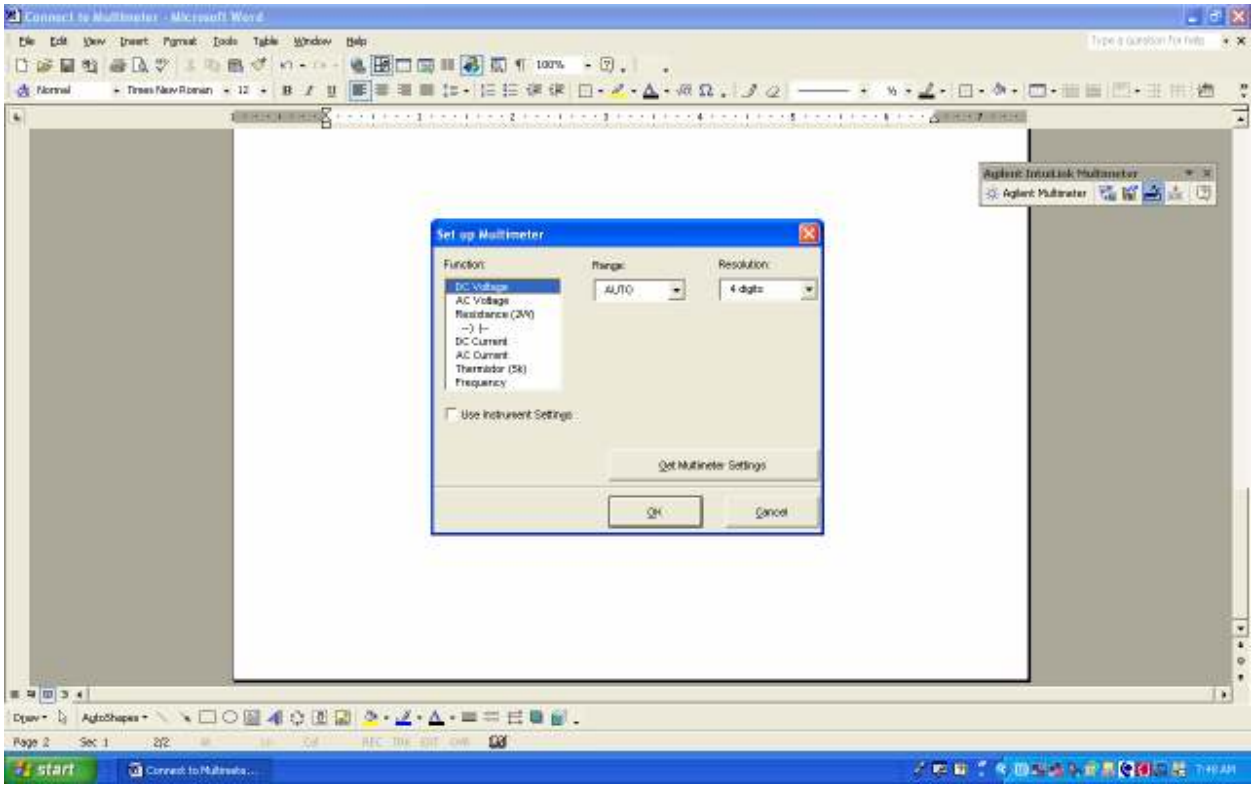
(Of course, you can move the toolbar out of the way as you need.)

5. Make certain that the USB connection is present from the PC to the Agilent Technologies 34405A Multimeter and that the power to the Multimeter is on.
6. Click the icon in the toolbar that indicates "Connect to Multimeter" and you will see the next window open.
7. You should see a listing of USB under the box for "Select Addresses." **(1)** Click on the USB address.
8. Next you should click the tab that says, "Identify Instrument(s)." **(2)** In the right-hand box you should then see "Multimeter" appear. **(3)**
9. Click the tab that says "Connect" **(4)** and then the window should then say "Connected." **(5)**

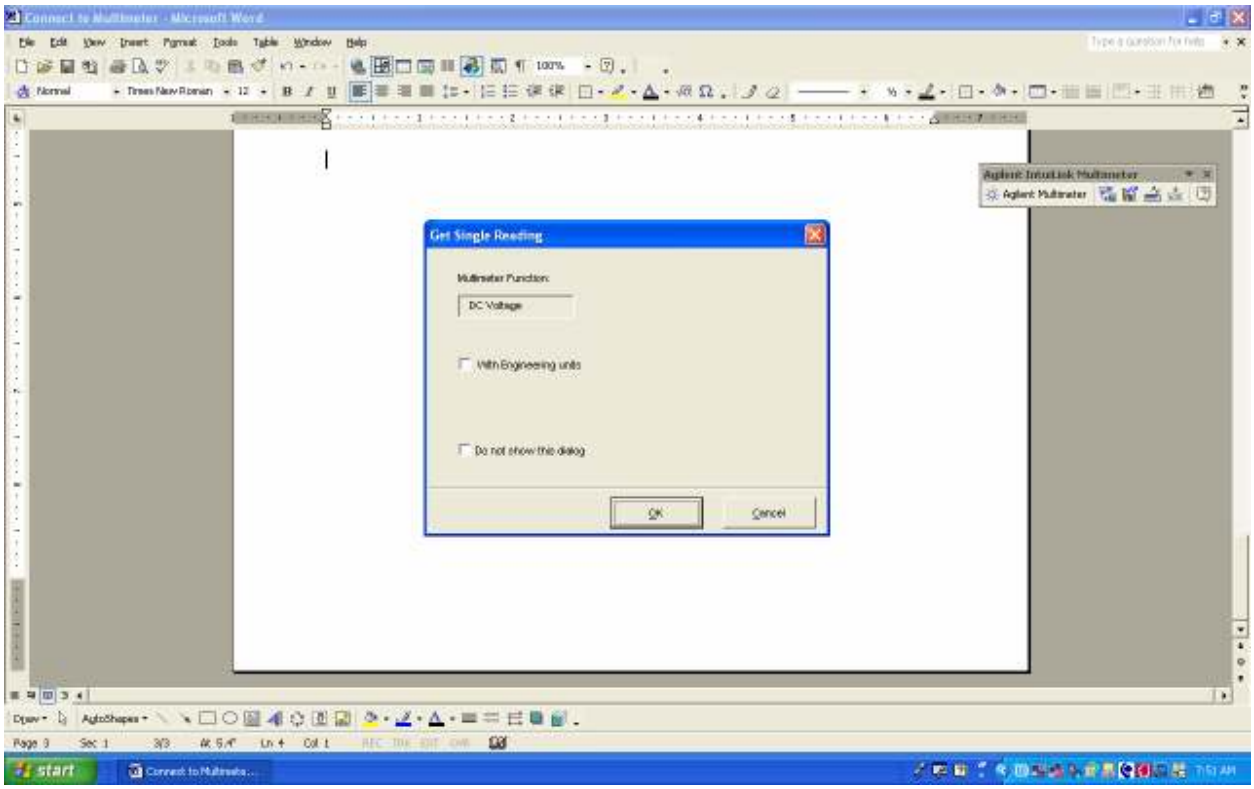


10. Next, close this window. **(6)**

11. Skip over the icon in the toolbar for "Save/Load Multimeter Settings" and click the icon for "Set up Multimeter."
12. Select the Multimeter Function, Range, Resolution as needed, or use the Instrument Settings. You can get the instrument settings as well. Click "OK" when you are done.



13. To get a single reading, click the icon in the toolbar for "Get Single Reading." You will see another window appear such as in this figure. It will indicate what sort of function the Multimeter is going to perform and will ask if you want Engineering Units or not. (My preference is generally to NOT use Engineering Units since I would like to be able to import the values collected here into Matlab.)
14. When you click "OK" you should then see appear in the open Word document a number appear where the cursor is. You may need to hit "Enter" on the keyboard or move the cursor around in a table in between measurements to delineate the numbers. Have fun!!



15. You should not close the Multimeter toolbar until you are done with taking measurements. Otherwise you will have to close the Word document completely and then start over.