HP 34401A Multimeter

- 6 1/2 digit, high performance digital multimeter
- AC/DC voltage measurements
- AC/DC current measurements
- 2 and 4 wire resistance measurements
- Frequency and Period measurements
- Math functions

Safety Tips

Protect Yourself:
Avoid contact with Voltage or Current Source.

1) Use shrouded test leads and alligator clips.
2) Connect leads to multimeter first.
3) Do all normal connect/disconnect at source.
4) Familiarize yourself with the manual.

Protect Instrument

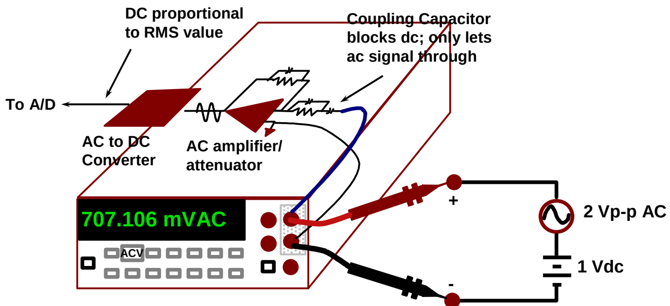
1) Inductive Devices (e.g. transformers, chokes/inductors) induce very high transient voltages.
2) Measuring resistance: Avoid contacting probes with live circuits when in resistance modes.
3) Measuring Current: Do not connect probes across voltage source.

Starting Multimeter

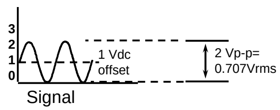
- *To perform a complete self-test, hold down the* shift *key for more than five seconds as you turn on the multimeter.*
- *The display will indicate whether test passed. Error messages will be displayed if a failure occurs.*

000.002 mVDC

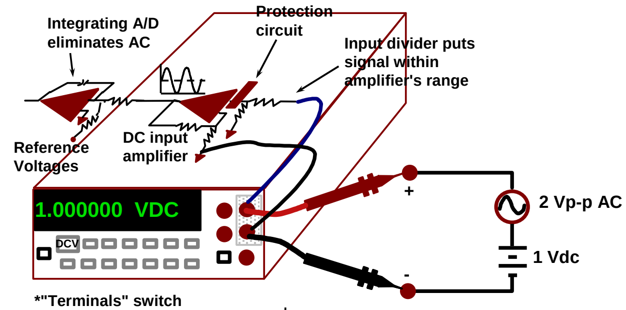
Measuring ACV



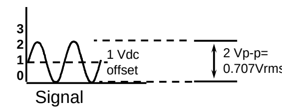
*"Terminals" switch in "FRONT"
* Press ACV
* Note measurement indicates only the ac portion of signal



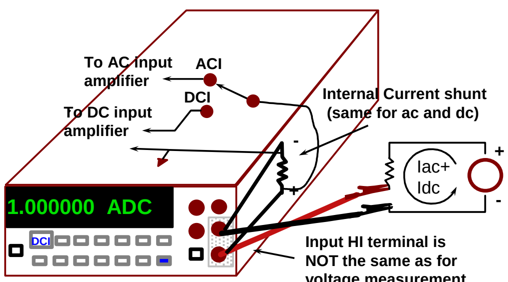
Measuring DCV



*"Terminals" switch in "FRONT"
* Press DCV
* Note measurement indicates only the dc portion of signal



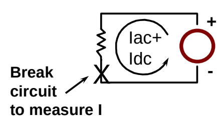
Measuring CURRENT



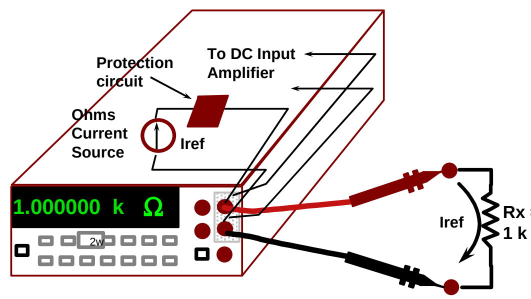
* SHIFT DCV = Measure DCI

* SHIFT ACV = Measure ACI

* Never hook current leads directly across a voltage source.



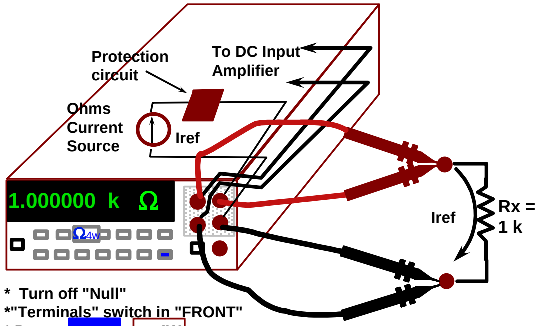
Measuring Resistance Two-Wire Technique



*"Terminals" switch in "FRONT"
* Press 2W
* Since voltage is sensed at front terminals, measurement includes all lead resistance

* To eliminate the lead resistance:
* Short leads together
* Press Null
* Original value will now be subtracted from each reading

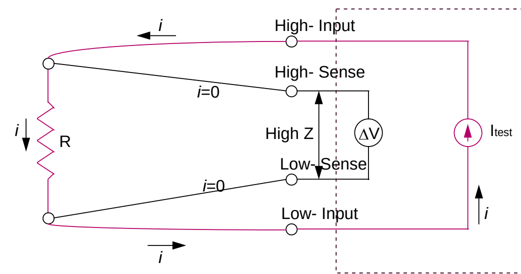
Measuring Resistance
Four-Wire Technique



* Turn off "Null"
*"Terminals" switch in "FRONT"
* Press [ ] 4W
* Voltage is now sensed directly at the resistor, so lead resistance is not a factor

* Because input impedance of DC Input Amplifier is so high, no current flows through sense leads, hence no lead resistance error

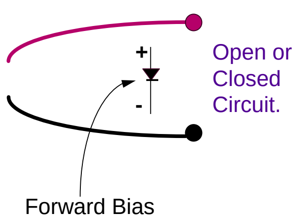
4-Wire Resistor Measurement



$\Delta V = I_{test} * R$

$R = \frac{\Delta V}{I_{test}}$

Continuity Test
& Diode Check

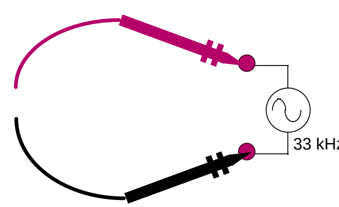


Cont = Continuity test

Shift [diode] = Diode check

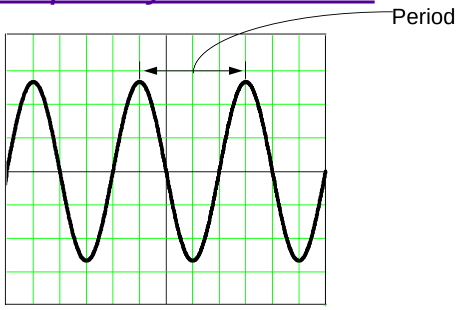
Measuring Frequency & Period

33.000,0 kHz



Freq = Measure Frequency
Shift Period = Measure Period

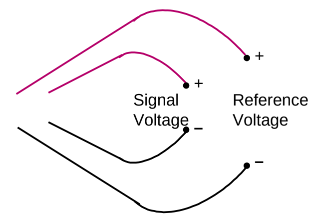
Frequency and Period



Frequency = 1/Period

Ratio Measurements

DCV : DCV



Ratio = $\dfrac{\textit{dc signal voltage}}{\textit{dc reference voltage}}$

*To enable ratio measurements, use the MEAS menu.

Range and Resolution

Range	100 mV	1 V	10 V	100 V	1000 V (750 VAC)
Maximum Resolution	100 nV	1 µV	10 µV	100 µV	1 mV (750 µVAC)

Resolution Choices & Integration Time

	Integration Time**		Resolution Choices	
	.02	PLC	Fast 4 Digit	Fastest, Least Accurate
	.2	PLC	Fast 5 Digit	
	1	PLC	* Slow 4 Digit	
Default →	10	PLC	* Slow 5 Digit * Fast 6 Digit	
	100	PLC	Slow 6 Digit	Slowest, Most Accurate

***** Equivalent to Pressing "Digits" key on front panel.
**In Power Line Cycles (PLC).

Integration times of .02 and .2 do not provide power-line noise rejection characteristics.

RMS: Root-Mean-Square

* RMS is a measure of a signal's average power. Instantaneous power delivered to a resistor is: P= $[v(t)]^2$/R. To get average power, integrate and divide by the period:

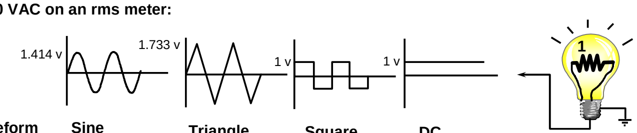
$$P_{avg} = \frac{1}{R}\left(\frac{1}{T}\int_{t_0}^{t_0+T}[v^2(t)]dt\right) = \frac{(V_{rms})^2}{R}$$

Solving for Vrms:

$$V_{rms} = \sqrt{\frac{1}{T}\int_{t0}^{t0+T}[v^2(t)]dt}$$

* An AC voltage with a given RMS value has the same heating (power) effect as a DC voltage with that same value.

* All the following voltage waveforms have the same RMS value, and should indicate 1.000 VAC on an rms meter:

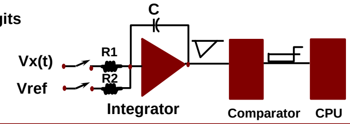


Waveform	Sine	Triangle	Square	DC
Vpeak	1.414	1.733	1	1
Vrms	1	1	1	1

All = 1 WATT

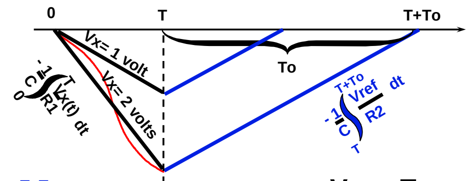
Measurement Principle: Integrating A/D

1) Converts voltage to time to digits
2) Integrator is a line-frequency filter
3) Integrator is a low-pass filter



Integrator:

$$V_{out} = -\frac{1}{C}\int_0^T i(t)\,dt$$

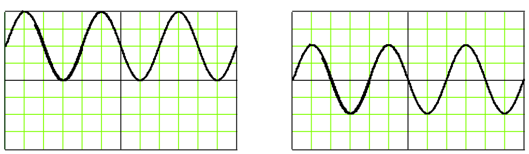


If R1=R2 ⇒ $\int_0^T V_x\,dt = \int_T^{T+T_o} -V_{ref}\,dt$ ⇒ T*Vx= To*(-Vref) ⇒ $\frac{V_x}{-V_{ref}} = \frac{T_o}{T}$

T is fixed at one cycle of 50 Hz or 60 Hz to eliminate line noise; Vref is fixed; R, C and Time are all ratioed, so accuracy is excellent.

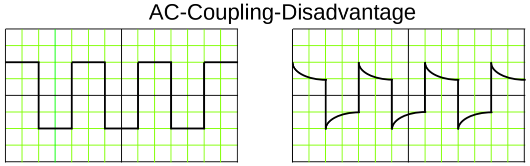
AC-Coupling vs. DC-Coupling

AC-Coupling-Advantage



*Removes DC Portion of Signal

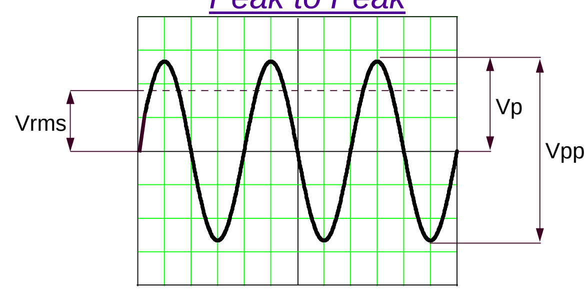
AC-Coupling-Disadvantage



*Low Frequency waveforms can be cut-off

Voltage measurements

Peak to Peak



Vrms = Vp * .707 (Sine wave)

The DIGITAL MULTIMETER

Hints for Accurate Measurements:

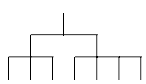
- Measure as near full scale as possible
- Use a Ratio measurement whenever possible.
- Before measuring, short the test leads together to check for offsets. (Exception: RMS AC measurements)

Advanced Functions &

Measurement Principles

Menu at a Glance

Menu is organized in a top-down tree structure with 3 levels



To turn on menu Shift On/Off

To move left or right < >

To move up or down V Λ

To enter command Auto / Man

A: Meas Menu ➡ B: Math Menu ➡ C: Trig Menu ➡ D: Sys Menu ➡ E: I/O Menu ➡ F: Cal Menu

1: AC Filter 2:Continuity ➡ 1: Min-Max ➡ 1: Read Hold ➡ 1: RDGS Store ➡ 1: HP-IB ADDR ➡ 1: Secured ➡

Math Functions

To make null (relative) measurement Null

To store min/max readings Min Max

To make dB measurements Shift dB

dB = *reading in dBm* - *relative value in dBm*

To make dBm measurements Shift dBm

dBm = $10*Log_{10}$ (*reading* ^{2}*/ reference resistance/ 1mW)*

Limit testing (Access through Menu)

Triggering

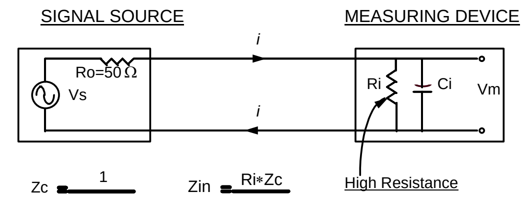
Auto-trigger: Continuously takes readings at fastest rate possible for present configuration. Default.

Single trigger: Manual trigger by pressing [Single]
One reading or specified number of readings (Sample count).

Number of samples: Number of readings meter takes with each trigger: 1 to 50,000. Default is 1.

Reading hold: Select by pressing [Shift] [Auto/Hold]
Captures and holds a stable reading on the display.

High Z Termination

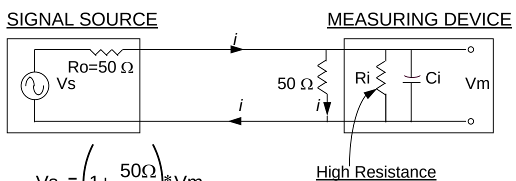


$$Zc = \frac{1}{j\,2\pi f\,C} \qquad Zin = \frac{Ri * Zc}{Ri + Zc}$$

$$Vs = \left(1 + \frac{Ro}{Zin}\right) * Vm \quad \text{.... for very large Zin, Vs} \cong \text{Vm}$$

As frequency increases, Zin decreases
For less than 1% error Zin $\geq$ 100 Ro

50 Ω Termination



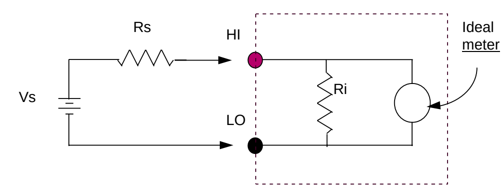
$$Vs = \left(1 + \frac{50\Omega}{50\Omega}\right) * Vm$$

$$Vs = 2 * Vm$$

$$Vm = \left(\frac{1}{2}\right) * Vs$$

*Vm will not equal Vs, if Zin = Ro, but the ratio between them is 2:1.

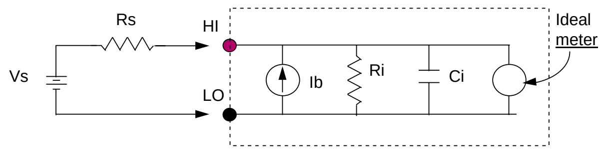
Loading Errors (DC volts)



Vs = ideal DUT voltage
Rs = DUT source resistance
Ri = multimeter input resistance
(10 MΩ or > 10 GΩ)

$$Error(\%) = \frac{100 * Rs}{Rs + Ri}$$

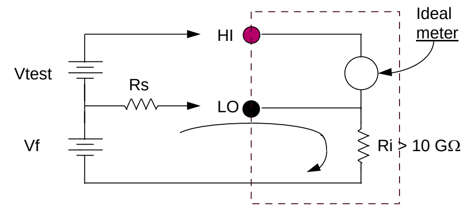
Leakage Current Errors



Ib = multimeter bias current
Rs = DUT source resistance
Ci = multimeter input capacitace

Error(v) $\cong$ Ib $*$ Rs

Common Mode Rejection (CMR)



Vf = float voltage
Rs = DUT source resistance imbalance
Ri = multimeter isolation resistance

$$\text{Error(v)} = \frac{\text{Vf} * \text{Rs}}{\text{Rs} + \text{Ri}}$$