**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.

**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

**Menu at a Glance**

Menu is organized in a top-down tree structure with 3 levels.
**Math Functions**

To make null (relative) measurement: Null

To store min/max readings:

To make dB measurements: Shift dB

\[ \text{dB} = \text{reading in dBm} - \text{relative value in dBm} \]

To make dBm measurements: Shift dBm

\[ \text{dBm} = 10 \times \log_{10} \left( \frac{\text{reading}}{\text{reference resistance} / 1\text{mW}} \right) \]

Limit testing (Access through Menu)

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**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.

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**Measuring DC Voltage**

1.000000 VDC

* Note measurement indicates only DC portion of signal

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**Range and Resolution**

<table>
<thead>
<tr>
<th>Range</th>
<th>100 mV</th>
<th>1 V</th>
<th>10 V</th>
<th>100 V</th>
<th>1000 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(750 VAC)</td>
</tr>
<tr>
<td>Resolution</td>
<td>100 nV</td>
<td>1 µV</td>
<td>10 µV</td>
<td>100 µV</td>
<td>1 mV (750 µVAC)</td>
</tr>
</tbody>
</table>

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**Resolution Choices & Integration Time**

<table>
<thead>
<tr>
<th>Integration Time*</th>
<th>Resolution Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 PLC</td>
<td>Fast 4 Digit</td>
</tr>
<tr>
<td>2 PLC</td>
<td>Fast 5 Digit</td>
</tr>
<tr>
<td>1 PLC</td>
<td>Slow 4 Digit</td>
</tr>
<tr>
<td>10 PLC</td>
<td>Slow 5 Digit</td>
</tr>
<tr>
<td>100 PLC</td>
<td>Slow 6 Digit</td>
</tr>
</tbody>
</table>

Default: Fastest, Least Accurate

* Fast 6 Digit: Slowest, Most Accurate

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**Measuring AC Voltage**

707.106 mVAC

* Note measurement indicates only the AC portion of signal

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* 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.
**AC Filter**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Range*</th>
<th>Time to settle</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Hz and above</td>
<td>Slow</td>
<td>7 sec.</td>
</tr>
<tr>
<td>20 Hz and above</td>
<td>Medium</td>
<td>1 sec.</td>
</tr>
<tr>
<td>200 Hz and above</td>
<td>Fast</td>
<td>0.1 sec.</td>
</tr>
</tbody>
</table>

*Selectable through the measurement menu

**AC-Coupling vs. DC-Coupling**

**AC-Coupling-Advantage**

*Removes DC Portion of Signal

**AC-Coupling-Disadvantage**

*Low Frequency waveforms can be cut-off

**Vrms: Root-Mean-Square**

- Instantaneous power to a resistor is: \( P = \frac{v(t)^2}{R} \)
- Average power to a resistor is:
  \[
  P_{avg} = \frac{V_{rms}^2}{R} = \frac{1}{T} \int_{t_0}^{t_0+T} \frac{v(t)^2}{R} \, dt
  \]

Solving for \( V_{rms} \):

\[
V_{rms} = \sqrt{\frac{1}{T} \int_{t_0}^{t_0+T} v(t)^2 \, dt}
\]

- A given \( V_{rms} \) AC has the heating (power) effect of a VDC with the same value.

**Voltage measurements**

**Peak to Peak**

\[
V_{rms} = V_p \cdot .707 \quad \text{(Sine wave)}
\]

**Measuring Current**

Internal current shunt (same for AC and DC)

\[
I = \frac{V}{\Delta V_r}
\]

1.000000 ADC

**Measuring Resistance 2-wire**

\[
1.000000 \, \Omega
\]

* Press [Ω 2W]

* Resistance measured includes lead resistance

* To eliminate the lead resistance:
  - Short leads together
  - Press [NULL]
  - Lead resistance will be subtracted from reading

* Never hook current leads directly across a voltage source
**Measuring Resistance 4-wire**

- Turn off "Null"
- Press \( \text{SHIFT} \) \( \Omega \) \( 4W \)

No error due to lead resistance

**4-Wire Resistor Measurement**

\[ \Delta V = \text{Itest} \times R \]

\[ R = \frac{\Delta V}{\text{Itest}} \]

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**Continuity Test & Diode Check**

- Open or Closed Circuit
- Forward Bias

Cont  = Continuity test
Shift  = Diode check

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**Measuring Frequency & Period**

33,000.0 kHz

Freq  = Measure Frequency
Shift  = Measure Continuity
Period  = Measure Period

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**Frequency and Period**

Frequency = 1/Period

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**Ratio Measurements**

DCV : DCV

\[ \text{Ratio} = \frac{\text{dc signal voltage}}{\text{dc reference voltage}} \]

To enable ratio measurements, use the MEAS menu.
### Voltage

**RMS vs. Peak**

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Vrms</th>
<th>Vp</th>
</tr>
</thead>
<tbody>
<tr>
<td>sine</td>
<td>1.0</td>
<td>1.414</td>
</tr>
<tr>
<td>triangle</td>
<td>1.0</td>
<td>1.733</td>
</tr>
<tr>
<td>square</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>DC</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* Peak voltage = 1/2 of Peak to Peak voltage

### High Z Termination

- **SIGNAL SOURCE**
- **MEASURING DEVICE**
- **Ro** = 50 Ω

\[
Z_{in} = \frac{1}{j \omega C}
\]

\[
Vs = \left( \frac{1}{\frac{1}{Ro} + \frac{1}{Z_{in}}} \right) Vm
\]

For less than 1% error \( Z_{in} \geq 100 \text{ Ro} \)

### Remote Interface

- **HP-IB** (IEEE-488) Address:
  - Address 31 is talk only mode.
  - Adjustable only through the I/O menu.
- **RS-232 Interface**:
  - Baud rate must be selected (I/O menu): 300, 600, 1200, 2400, 4800, or 9600.
  - Parity selection (I/O menu): Even or Odd

### Loading Errors (DC volts)

\[V_s = \text{ideal DUT voltage}
\]

\[R_s = \text{DUT source resistance}
\]

\[R_i = \text{multimeter input resistance}
\] (10 kΩ or > 10 GΩ)

Error(%) = \( \frac{100 \times R_i}{R_s + R_i} \)

### Leakage Current Errors

\[I_b = \text{multimeter bias current}
\]

\[R_s = \text{DUT source resistance}
\]

\[C_i = \text{multimeter input capacitance}
\]

Error(v) = \( I_b \times R_s \)
**Common Mode Rejection (CMR)**

$V_{f} = \text{float voltage}$

$R_{s} = \text{DUT source resistance}$

$R_{i} = \text{multimeter isolation resistance}$

Error($V$) = $V_{f} \cdot R_{s} / (R_{s} + R_{i})$

**Noise caused by Ground Loops**

$R_{l} = \text{lead resistance}$

$R_{i} = \text{multimeter isolation resistance}$

$V_{\text{ground}} = \text{voltage drop on ground bus}$

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**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)

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**Where to get more information**

- HP 34401A User’s Guide
- HP 34401A Service Guide
- For on-line technical information call HP Direct at 1-800-452-4844