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Multimeters


EECS 100

Multimeters are used to check voltages and currents in a circuit. Most also measure resistance. Battery powered handheld multimeters are typically accurate to a fraction of a percent. Desktop versions are more accurate and expensive.



The diagram on the last page shows the front panel of the 34401A multimeter used in the EE 100 laboratory. Before performing a measurement the appropriate function must be selected. In this guide we discuss how to measure

- DC voltage
- DC current
- Resistance

Continuity test  is a variant of resistance measurement where the instrument “beeps” if the resistance is small and is silent otherwise. This feature is very convenient when tracking down wiring errors in circuits.

DC stands for direct current and simply means that the current is constant and does not change direction. AC or alternating current changes direction periodically. For example, household current is sinusoidal and changes direction 60 times per second in North America (50 times in the rest of the world).

Measuring DC Voltage with the Multimeter

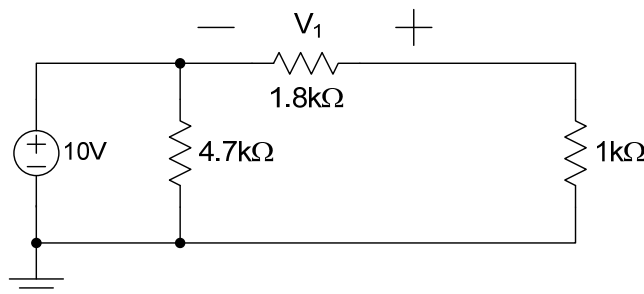


Figure 1 Circuit for checking out the multimeter.

Let's use the circuit from Figure 1 to check out the multimeter. Connect the test leads as shown in Figure 2 and press DC V to configure the instrument for measuring DC voltage. It is customary to use a black lead for the negative and red lead for the positive terminal of the meter, but of course any color will work. Now measure the voltage V_1 by placing the red lead on left and the black lead on right terminal of the resistor. As you can easily verify the correct reading is $-6.43V$. If you reverse the test leads you get a positive voltage. Measure the voltage across the other resistors and the voltage source and compare to calculated values.

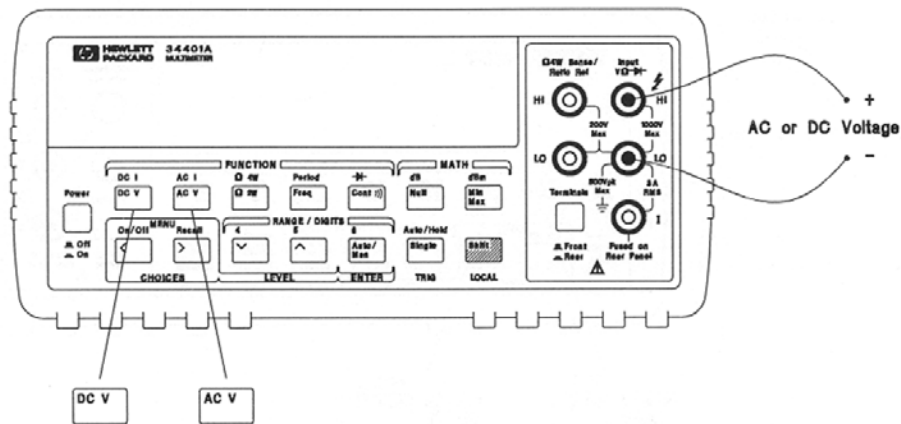


Figure 2 Test leads for measuring voltage or resistance.

Ideally the voltmeter is an open circuit and now current flows through it when measuring voltage. This is important to get an accurate reading. In practice voltmeters have a finite internal resistance of e.g. $10M\Omega$. Thus a current of $6.43V/10 M\Omega = 0.643\mu A$ is flowing when measuring $6.43V$. For the measurement in Figure 1 this produces a negligible error, but as with all measurements we have to be careful to account for the effect of the measurement on the circuit we are testing. Some voltmeters (including the 34401A) can be put into a “high resistance mode” to reduce this effect (check the manual for details).

Measuring DC Current with the Multimeter

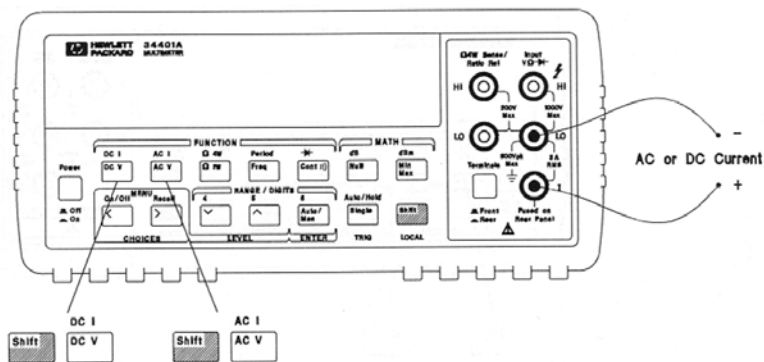


Figure 3 Connections for current measurements.

Now let's measure the current flowing through the $1.8k\Omega$ resistor. Disconnect the test leads and connect them to the instrument as shown above in Figure 3. Then choose the “DC I” function of the instrument. Current flows in wires and to measure it we have to break the wire and insert the instrument, as shown below in Figure 4. The reading is $3.57mA$. Again, reversing the test leads changes the sign measured current.

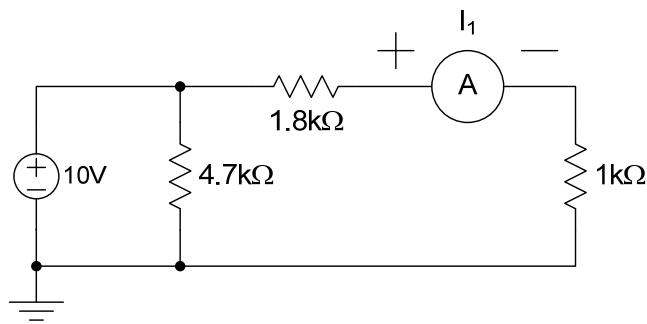


Figure 4 Circuit for measuring current. The circle with the A inside represents the ampere meter.

Ideally inserting the ampere meter should not change the circuit. This would be the case if the ampere meter was a perfect short circuit (a 0Ω resistor). In reality the resistance is not quite zero but comes close. From this it should be clear that the meter should always be inserted in series with circuit components as shown in Figure 4.

Inserting the A-meter between nodes, as shown in Figure 3, alters the circuit and hence makes no sense: since the meter is (ideally) a short circuit inserting it introduces a new path in the circuit for current to flow. In the particular (unlucky) arrangement the instrument puts a short across the 10V source, causing a large and possibly damaging current to flow. Unless the current is limited by the supply (e.g. by setting the current compliance; always a good idea as evidenced by this example!), the meter may be damaged or its fuse blows. As a courtesy to other students, please let the TA know if you accidentally burn a fuse or an instrument is not working properly so he can have it repaired.

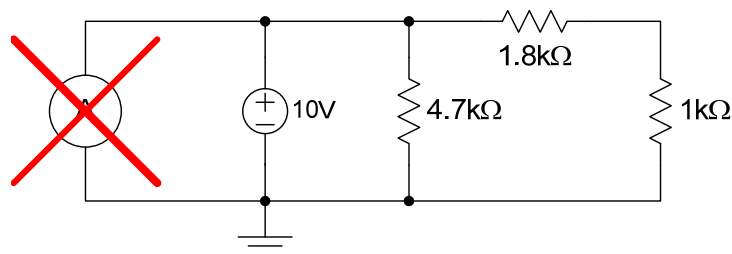


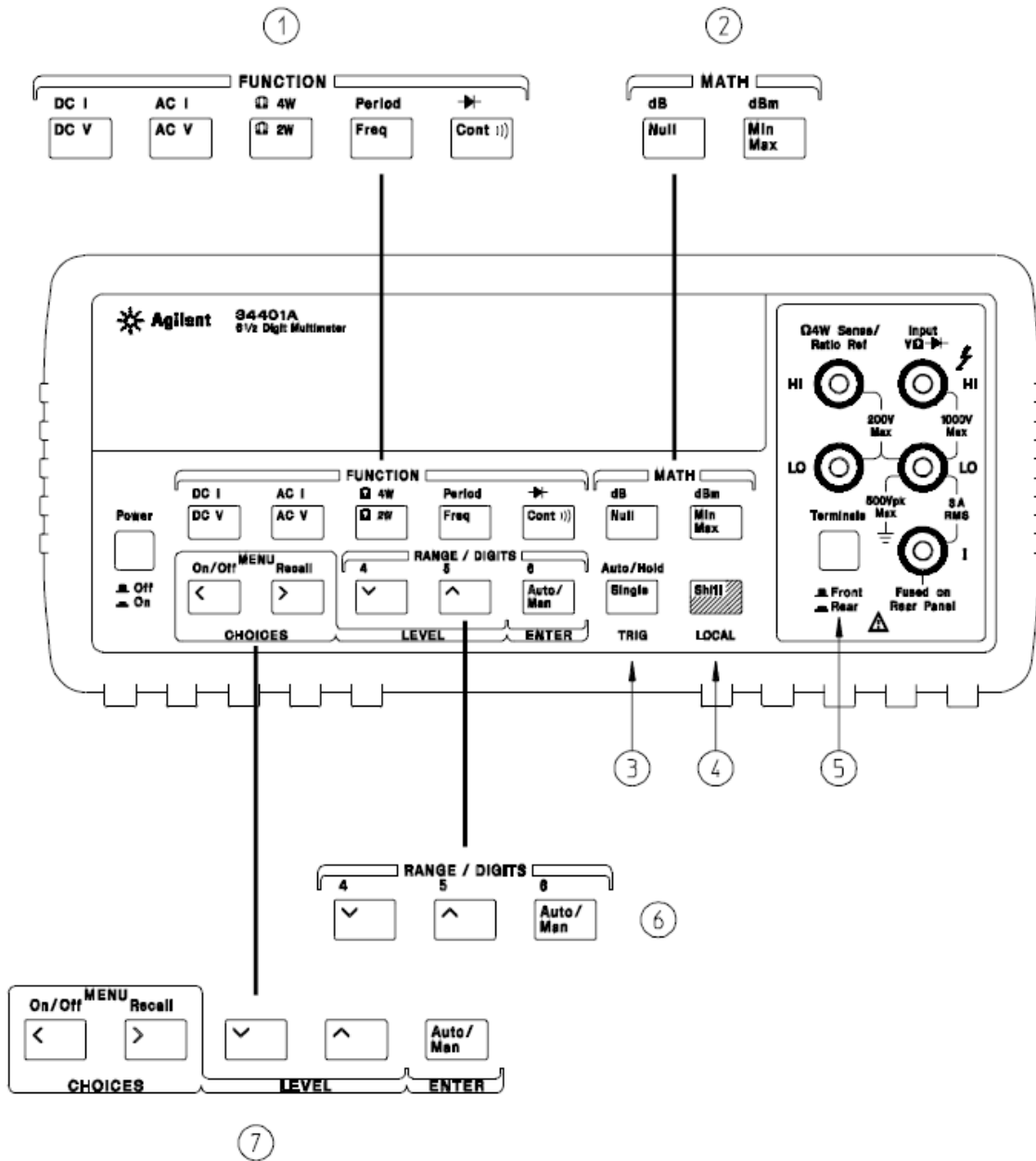


Figure 3 Incorrect (and meaningless) connections of the ampere meter damage the instrument.

Measuring Resistance with the Multimeter

Before measuring resistance or testing continuity, first turn off the power if the component you are testing is inserted in a circuit. Otherwise the reading will be incorrect and the meter may be damaged. Press  and connect the test leads as shown in Figure 2 (same test lead configuration for measuring DC voltage). To make resistance measurements, the instrument sends a small current through the device under test and measures the voltage that develops (the table on page 216 of the user guide shows the values used by the 34401A). After pressing the  button, just connect your component in series to the probes and see the result. If you see 'OVL'D', that means that there is an infinite resistance between the two ends of the probes.



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|---|---|
| 1 Measurement Function keys | 5 Front / Rear Input Terminal Switch |
| 2 Math Operation keys | 6 Range / Number of Digits Displayed keys |
| 3 Single Trigger / Autotrigger / Reading Hold key | 7 Menu Operation keys |
| 4 Shift / Local key | |