Using a Multimeter

Introduction

The humble multimeter can be used for many different tasks and you should become completely familiar with operation and the necessary precautions as quickly as possible. These notes refer to the specific multimeter that I use but are generally applicable to all similar multimeters found in schools and workshops.

The multimeter has four connections and a dial to select the functionality. It is important to set the multimeter to the correct function and connect the probe wires correctly **before** connecting the multimeter to your circuit. As with all measuring instruments, **build the circuit, then add the measuring instruments**.

Checking for continuity

This function allows you to check that a circuit has a very low resistance - i.e. that it is, in effect, a continuous piece of wire. This is useful for checking cables that you have made such as those used with instruments of both varieties - either a probe lead for your oscilloscope or a stage lead for your electric guitar. It is also useful for checking fuses are still good and haven't blown.

The continuity tester can be used to determine which connections are normally open (NO) and normally closed (NC) on a switch or relay. The continuity function is essential for checking the integrity of earth connections etc. The continuity tester can also be used for testing diodes - they will register as continuous in only one direction.

Select the function as shown. On this multimeter the symbol is a diode (because it can be used to test diodes) with a musical note next to it (because it makes a sound when the test circuit is continuous). Connect the wires to the COM and "Ohm" terminals. Touching the probe leads together should result in a tone and a low resistance reading indicating that the circuit is a continuous conductor.

Measuring D.C. voltage

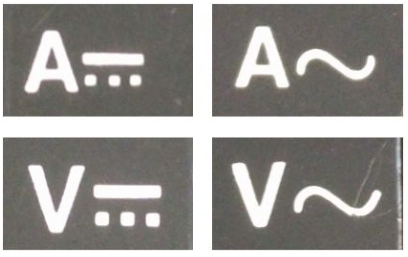
To measure D.C. voltage connect the probe leads to the COM and the Voltage connections as shown. Select the voltage scale suitable for the voltage you expect to measure. The scale tells you the absolute maximum voltage that can be measured and displayed. For example, selecting the 2 V scale allows you to measure voltages up to but not including 2 volts i.e. up to 1.999 V. The reason for this slightly unusual choice of maximum value is that the 4th digit (the most significant digit) on the display is actually only part of a 7-segment display and can only display the digit "1". If the correct scale has been selected, the result will be shown in either volts or mV. If the value measured is 'out of range', the display shows just the "1" and nothing else - in this case choose a more suitable scale.

Note: The multimeter will measure both Potential Difference and EMF and both of these quantities are simply referred to as 'voltage' even though this is not strictly correct.

Note: As all voltages in a circuit are measured relative to 0 V, it is often more convenient to simply connect the COM connection on the multimeter to the 0 V on the power supply. This means you only need to make one connection with the probe to the actual circuit.

Measuring A.C. voltages is very similar to measuring D.C. voltages. The multimeter uses the same connections but the A.C. function is selected instead. Note that the multimeter samples the A.C. signal and so, if you try to measure an A.C. signal with a high frequency, the display tends to change quite rapidly and does not yield any meaningful information. The A.C. ranges measure the RMS voltage, not the peak voltage.

Selecting the correct setting



The icons on the top row are the correct settings for measuring current (A) with the D.C. current setting on the left and the A.C. current setting on the right.

The A.C. symbol is a sine wave and the D.C. symbol is a constant value (solid line) above some reference such as zero volts (dotted line).

The icons on the bottom row are the correct settings to measure D.C. voltage (left) and A.C. voltage (right).

Selecting the correct scale

The correct scale to use is the scale that has the lowest maximum value without actually going out of range. This applies to voltage, current and resistance readings. The display has three full digits and a "1" as the most significant digit so the biggest number that can be displayed is 1999.

Consider a multimeter being used to read a voltage of 0.314 V which is 314 mV. The options are:

- **200 mV scale:** In this case the voltage being measured (314 mV) is greater than the maximum that can be measured (199.9 mV) so the multimeter would be out of range
- **2 V scale:** The maximum voltage that can be displayed is 1.999 V on this setting so the display would show 0.314 V
- **20 V scale:** The display can show 19.99 V which is now only two decimal places. The display would therefore show 0.31 V which is less precise than using the 2 V scale
- **200 V scale:** The maximum voltage that can be displayed is 199.9 V i.e. only one decimal place. In this example the display would show 0.3 V
- **1000 V scale:** The maximum voltage that can be displayed is 1999 V but the input should not exceed 1000 V. There are no decimal places and so the display would read, in this case, 0 V

When measuring a voltage of 0.314 V the best scale to use is the 2 V scale because it has the best level of precision. This is the scale with the lowest maximum value (1.999 V) without actually going out of range.

Measuring D.C. Current

Measuring current is slightly complicated by the fact that the current measuring part of the multimeter, i.e. the ammeter function, is protected by a fuse. This is because the ammeter connection has a very low resistance and the multimeter would be damaged if it were inadvertently connected in parallel with a power supply (to measure voltage) whilst connected as an ammeter. Unfortunately it is not immediately obvious if the fuse has blown.

To measure current, connect the probe leads to the COM and the mA connections as shown and select a suitable current range. Once the multimeter is correctly configured, connect it in series in the circuit. It is often more convenient to use 4mm wires and crocodile clips rather than the probe leads.

Measuring high currents

To measure high currents, greater than 2 A, swap the connections so that the COM and 10 A connections are used. Select a corresponding current range and proceed with some caution! It is interesting to note that, if you are measuring a current reading of, say, 1.0 A in a simple circuit, the two different current ranges that could be used i.e. 2 A range and 10 A range, will give slightly different values for the current. This is not a fault of the multimeter as such but simply the fact that the 10 A range has a lower resistance than the 2 A range and so has less effect on the circuit being measured.

Measuring A.C. currents is similar to measuring A.C. voltages in that the RMS value is displayed and there is a limit to the frequency of the signal that can be reliably measured. The multimeter is perfectly reliable at low frequencies and will easily measure A.C. Currents at 50 Hz, which is a very common measurement. Measuring low frequency signals such as 1 Hz will be problematic as will measuring high frequency current - the multimeter samples the data and cannot always provide a reliable reading with the display changing almost randomly.

Testing the fuse

If, after connecting the multimeter to measure current, the reading remains stubbornly at zero and the circuit refuses to work it is very likely that the fuse in the multimeter has blown. Note that the multimeter will still measure voltage and resistance with the fuse blown, it is only current measurements that are affected by a blown fuse. To test the fuse, use a second multimeter to measure the continuity between the COM and the 2 A connections (or the 10 A connection). If there is not a continuous circuit between the two terminals you will have to disassemble the multimeter to change the fuse!

Measuring resistance

To measure the resistance of a component the multimeter provides a small voltage and measures the corresponding current before calculating the effective resistance. For this reason, the multimeter cannot be used to measure the resistance of components in a live circuit - disconnect the power before measuring the resistance between two points in a circuit. The multimeter also measures the total resistance between the two probe leads, therefore, if the meter is used to measure the value of a resistor in a circuit it will often give an erroneous result as the combined effect of other circuit components are also included in the reading. If you want to measure the resistance of a single component reliably, physically take it out of the circuit.

To measure resistance, connect the probe leads to COM and "Ohm" and connect the multimeter in parallel with the component being tested. As with voltage and current, the function selector should be set to the most appropriate range to give the greatest level of precision. For example, consider each of the following settings used to measure a resistance of approximately 1 kΩ:

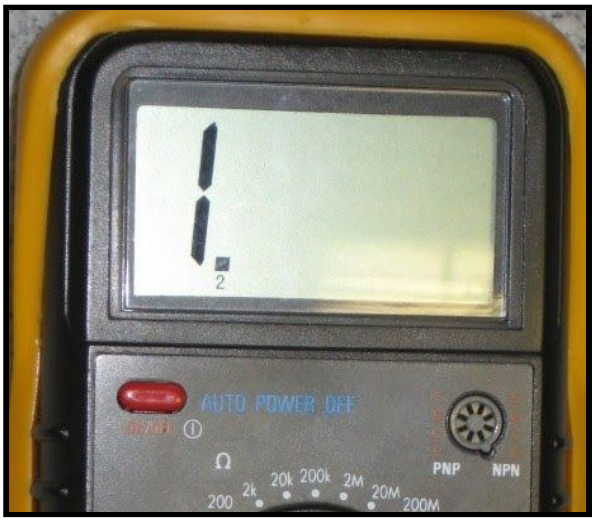
- 200 Ω - out of range
- 2 kΩ - ideal
- 20 kΩ - okay but not precise
- 200 kΩ - poor, limited precision
- 2M Ω - unlikely to provide a valid reading
- 20 MΩ - reads zero
- 200 MΩ- reads zero

So the 2 kΩ setting will have the greatest precision and give the most reliable reading.

Other functionality

The multimeter can also test npn and pnp transistors. Inserting a transistor into the socket and selecting the hFE function will give the current gain of the transistor if it is working correctly and is connected correctly. Hence this function can be used to test bipolar transistors, match pairs of transistors and check the pin layout.

Out of Range



The picture shows the display you are likely to get if your multimeter is out of range. This means what you are trying to measure is bigger than the display can handle. on a 3 ½ digit display the maximum value displayed is 1999 as the 1 is the half digit. Therefore, if the meter is on the 2 V setting, any voltage above 1.999 V will display "1" - out of range

Website

http://www.pfnicholls.com/Electronics/multimeter.html

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