Back to the Seventies with Ammeters and Voltmeters

Picture the following (somewhat unlikely) scene. BBC television remakes hit police drama *Life on Mars* but transfers the setting to a physics department. It is 1973. In an attempt to get the detail correct, the male teachers wear flared trousers, there are Ford Cortinas and Vauxhall Vivas in the car park and different set-ups for measuring current and voltage depending on whether the resistance to be investigated is low or high. We smile wryly at the cars and fashion and are thankful that modern digital meters have removed the necessity for the different circuits. Or have they?

A query came in to SSERC just before Easter. A class had been investigating the characteristics of a semiconductor diode. When it was forward-biased, the resulting I/V graph was as expected. On reverse bias, however, the results seemed very much at odds with the theory that the leakage current was "fairly independent" of the p.d. Indeed, the diode appeared to be ohmic in its behaviour, with a resistance of around a mega ohm. It turned out that the pupils had been using the circuit in Figure 1.

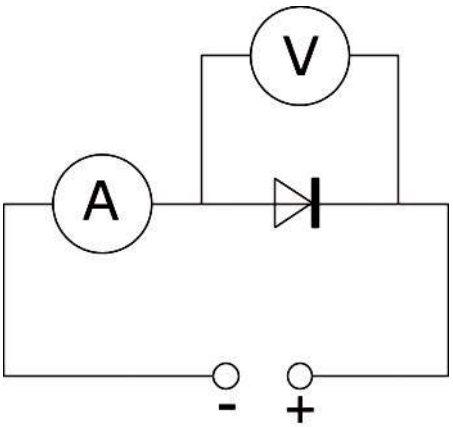

Figure 1 - Ammeter and voltmeter in "normal" positions.

This circuit is fine provided the resistance of the voltmeter is very much higher than that of the diode. If not, the current through the voltmeter will be comparable or greater than that through the component. We carried out the above experiment, using a variable d.c. power supply and a Rapid DMM212 meter set at 20 V. The I/V graph was a convincing straight line with a gradient that suggested a resistance of around a mega ohm. The experiment was then repeated with the meter connected as shown in Figure 2.

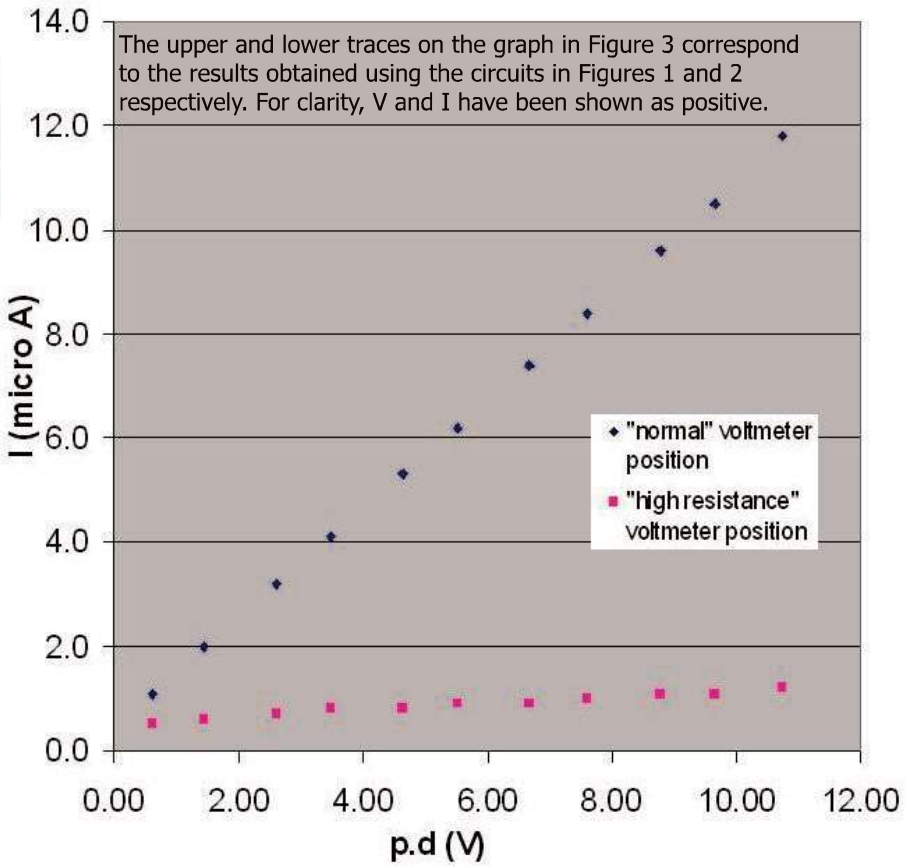

Figure 3 - Results from the two circuits.

The difference was far less marked when we repeated both investigations using the higher-specification Rapid DMM310 meter. Further investigations confirmed a 310DMMM has an impedance of around 10 MΩ and a 212DMM an impedance of approximately 1 MΩ. In most classroom situations, these meters can therefore be used in parallel with the component if the p.d. across the component is to be measured. Exceptions are when current is also being measured and the component has an impedance comparable to or greater than that of the meter. Another situation where this might occur is when investigating an LDR in darkness. Note that in the "high resistance" circuit of Figure 2, there will be a p.d. across the ammeter. This will lead to an inaccurate reading of the potential difference across the diode. Given the relative resistances of the ammeter and the reverse-biased diode, this will have a negligible effect.

The culprit responsible for the pupils' misleading results was thus almost certainly a wrongly-positioned voltmeter. To which we can only say, in the words of The Sweeney's Jack Reagan, "Get yer trousers on, you're nicked!"

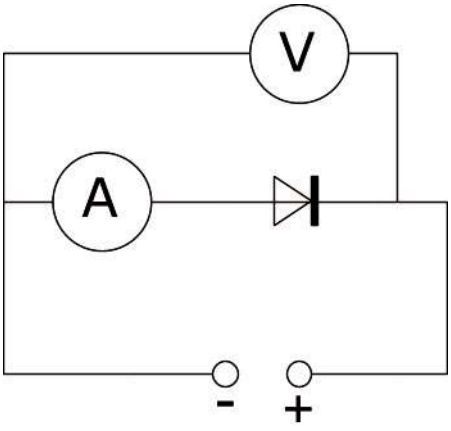

Figure 2 - Ammeter and voltmeter in "high resistance" positions.

Figure 4 - Rapid 212 digital multimeter