

incoming signal, and drive the auto-polarity (“+” or “-”) numeric display are readily available at modest cost from a number of manufacturers. These and other circuits have been integrated into a wide range of commercially available instruments. Inexpensive digital multimeters with very good accuracies are readily available. More expensive models may feature a wider range of readings, higher resolution, true rms AC measurement, better accuracy, auto-ranging (the meter displays the most appropriate range rather than the user choosing it), frequency counter, a transistor tester, a diode tester, capacitance measurement and sometimes even a built-in function generator.

Since the DMM is constructed around a DVM, a voltage meter, the measurement of current and resistance is fairly straightforward. To read current, the DMM is placed in the circuit so that current flows through the meter circuitry. When current measurement is selected, the current passes through a precision resistor causing a voltage drop equal to the value of the current multiplied by the value of the resistance. This voltage is connected internally across the input of the analog-to-digital converter which reads the voltage. Since the resistance is known and the voltage is measured, the voltmeter can display the current directly. For a resistance measurement, the meter circuitry passes a known current through the resistor whose value is to be measured. A voltage drop equal to the product of this current and the value of the unknown resistance is produced across the meter’s terminals and is measured by the analog-to-digital converter. Similar to the current measurement, the resistance measurement is displayed directly on the face of the meter.

There are five important parameters which describe the digital multimeter: number of digits, range, resolution, accuracy and input impedance.

Number of Digits: Figure 6.9 shows a 3-1/2 digit, a 4-1/2 digit and a 6-1/2 digit display. Most inexpensive meters have 3-1/2 digit displays, which are adequate for many testing purposes. As the number of digits in the display increases, so does the cost of the instrument, often rather dramatically. The digit to the left (the most significant digit) is considered a “half” digit since it can only display the value of 0 or 1. The remaining digits can display any value from 0 to 9.

Range: Because the display can indicate 0 to 1999 for a 3-1/2 digit meter, the range of readings is indicated by the maximum value plus one least significant digit, which for voltage is usually 200 mV, 2 V, 20 V, 200 V and 2000 V. Resistance ranges are normally 200 Ω , 2 k Ω , 20 k Ω , 200 k Ω , 2 M Ω and 20 M Ω . These voltage and resistance ranges are fairly common even for the expensive 6-1/2 digit meters. Usually the maximum current measured by a DMM is 2.0 A, but 10.0 A models are available (with decreased resolution). The lower limit of current measurement varies widely among meters, with 200 mA being a common minimum range, but meters which can measure in the 200 μ A range can be easily found.

Resolution: Resolution is the value of the least significant digit (the one most to the right). For example, a 4-1/2 digit meter which has a lowest voltage range of 200 mV is expected to have a best DC voltage resolution of 0.01 mV (199.99 mV maximum reading on this range) or 10 μ V, whereas a 3-1/2 digit meter would have a best DC voltage resolution of 100 μ V (199.9 mV maximum). Note that a 6-1/2 digit meter would have a resolution of 0.1 μ V, a resolution 1000 times finer than the much less expensive 3-1/2 digit meter.

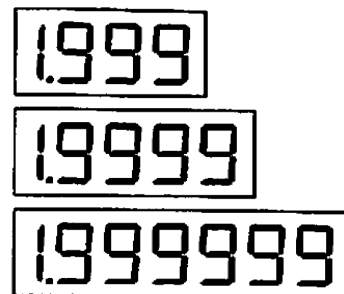


FIGURE 6.9 Display of 3-1/2, 4-1/2 6-1/2 digit DVMs.

Accuracy: Accuracy specifications are usually better than 1% for most digital meters, even the inexpensive 3-1/2 digit meter. The accuracy of a digital meter is usually presented as an addition of two percentages, namely % of reading + % full scale. A bottom-of-the-line, hand-held 3-1/2 digit meter might have an accuracy of \pm (0.8% of reading + 0.2% of full scale), whereas a top-of-the-line, bench-top 4-1/2 digit meter could have a rating of \pm (0.6% of reading + 0.06% full scale). Sometimes the accuracy of the meter is given as a percentage of the reading and a number of least significant digits. An example of this is a 6-1/2 digit meter which claims an accuracy of \pm 0.5% of reading \pm 20 in the last two digits. Because of the quantization of the signal being measured, even a perfect digital meter can have an accuracy no better than \pm 1/2 of the value of the last digit.

Input Impedance: Unlike the analog meter, the digital meter usually has a fixed-input impedance which is the same for all voltage ranges (sometimes, however, there is an aberration in the very low voltage range which is worth noting). Common input impedances are 1 M Ω and 10 M Ω . A simple scheme sometimes used to accomplish this is shown in Figure 6.10. Note that for

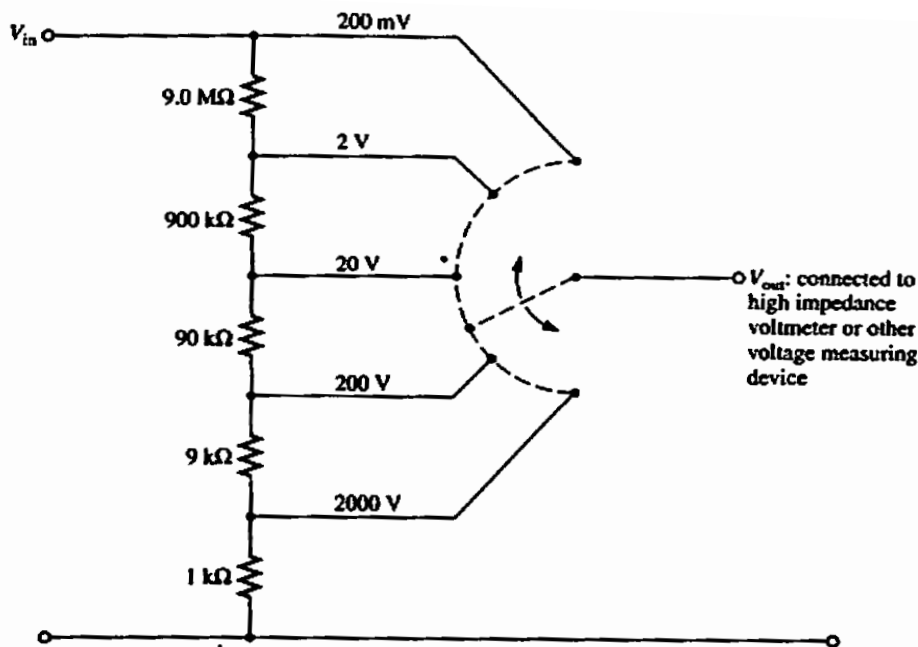


FIGURE 6.10 Voltage divider scheme for constant input impedance over 5 voltage ranges in a DVM.

each range the input impedance is the series sum of the five resistors, 10 M Ω (assuming that the circuitry that follows the switch has a very large impedance with respect to 10 M Ω) and that the A/D converter circuitry only needs to measure a small voltage range, normally from 0 to 200 mV, for any of the ranges.

According to most available literature, the parameter which describes the input impedance of the meter during a current measurement is usually the voltage drop at full scale, but sometimes the actual value of the input impedance is given. For the best meters this voltage drop is about 200 mV, and for the least expensive it is about 350 mV. If the introduction of a voltage drop of this magnitude is significant to your measurement, then careful analysis which includes the induced voltage drop is in order, or a less detrimental measurement technique must be found.