DIGITAL AND ANALOG MULTIMETER

- **Digital**

The resolution of a multimeter is often specified in "digits" of resolution. For example, the term 5½ digits refers to the number of digits displayed on the display of a multimeter.

By convention, a half digit can display either a zero or a one, while a three-quarters digit can display a numeral higher than a one but not nine. Commonly, a three-quarters digit refers to a maximum value of 3 or 5. The fractional digit is always the most significant digit in the displayed value. A 5½ digit multimeter would have five full digits that display values from 0 to 9 and one half digit that could only display 0 or 1.[3] Such a meter could show positive or negative values from 0 to 199,999. A 3¾ digit meter can display a quantity from 0 to 3,999 or 5,999, depending on the manufacturer.

While a digital display can easily be extended in precision, the extra digits are of no value if not accompanied by care in the design and calibration of the analog portions of the multimeter. Meaningful high-resolution measurements require a good understanding of the instrument specifications, good control of the measurement conditions, and traceability of the calibration of the instrument.

Specifying "display counts" is another way to specify the resolution. Display counts give the largest number, or the largest number plus one (so the count number looks nicer) the multimeter's display can show, ignoring a decimal separator. For example, a 5½ digit multimeter can also be specified as a 199999 display count or 200000 display count multimeter. Often the display count is just called the count in multimeter specifications.

Analog

Resolution of analog multimeters is limited by the width of the scale pointer, vibration of the pointer, the accuracy of printing of scales, zero calibration, number of ranges, and errors due to non-horizontal use of the mechanical display. Accuracy of readings obtained is also often compromised by miscounting division markings, errors in mental arithmetic, parallax observation errors, and less than perfect eyesight. Mirrored scales and larger meter movements are used to improve resolution; two and a half to three digits equivalent resolution is usual (and is usually adequate for the limited precision needed for most measurements).

Resistance measurements, in particular, are of low precision due to the typical resistance measurement circuit which compresses the scale heavily at the higher resistance values. Inexpensive analog meters may have only a single resistance scale, seriously restricting the range of precise measurements. Typically an analog meter will have a panel adjustment to set the zero-ohms calibration of the meter, to compensate for the varying voltage of the meter battery.

Digital multimeters generally take measurements with accuracy superior to their analog counterparts. Standard analog multimeters measure with typically three percent accuracy,[4] though instruments of higher accuracy are made. Standard portable digital multimeters are specified to have an accuracy of typically 0.5% on the DC voltage ranges. Mainstream bench-top multimeters are available with specified accuracy of better than ±0.01%. Laboratory grade instruments can have accuracies of a few parts per million.[5]

Accuracy figures need to be interpreted with care. The accuracy of an analog instrument usually refers to full-scale deflection; a measurement of 10V on the 100V scale of a 3% meter is subject to an error of 3V, 30% of the reading. Digital meters usually specify accuracy as a percentage of reading plus a percentage of full-scale value, sometimes expressed in counts rather than percentage terms.

Quoted accuracy is specified as being that of the lower millivolt (mV) DC range, and is known as the "basic DC volts accuracy" figure. Higher DC voltage ranges, current, resistance, AC and other ranges will usually have a lower accuracy than the basic DC volts figure. AC measurements only meet specified accuracy within a specified range of frequencies.

Manufacturers can provide calibration services so that new meters may be purchased with a certificate of calibration indicating the meter has been adjusted to standards traceable to, for example, the US National Institute of Standards and Technology (NIST), or other national standards laboratory.

Test equipment tends to drift out of calibration over time, and the specified accuracy cannot be relied upon indefinitely. For more expensive equipment, manufacturers and third parties provide calibration services so that older equipment may be recalibrated and recertified. The cost of such services is disproportionate for inexpensive equipment; however extreme accuracy is not required for most routine testing. Multimeters used for critical measurements may be part of a metrology program to assure calibration

Sensitivity and input impedance

When used for measuring voltage, the input impedance of the multimeter must be very high compared to the impedance of the circuit being measured; otherwise circuit operation may be changed, and the reading will also be inaccurate.

Meters with electronic amplifiers (all digital multimeters and some analog meters) have a fixed input impedance that is high enough not to disturb most circuits. This is often either one or ten megohms; the standardization of the input resistance allows the use of external high-resistance probes which form a voltage divider with the input resistance to extend voltage range up to tens of thousands of volts.

Most analog multimeters of the moving-pointer type are unbuffered, and draw current from the circuit under test to deflect the meter pointer. The impedance of the meter varies depending on the basic sensitivity of the meter movement and the range which is selected. For example, a meter with a typical 20,000 ohms/volt sensitivity will have an input resistance of two million ohms on the 100 volt range (100 V * 20,000 ohms/volt = 2,000,000 ohms). On every range, at full scale voltage of the range, the full current required to deflect the meter movement is taken from the circuit under test. Lower sensitivity meter movements are acceptable for testing in circuits where source impedances are low compared to the meter impedance, for example, power circuits; these meters are more rugged mechanically. Some measurements in signal circuits require higher sensitivity movements so as not to load the circuit under test with the meter impedance.