

# PRINCIPLE AND TYPES OF ANALOG AND DIGITAL INSTRUMENTS

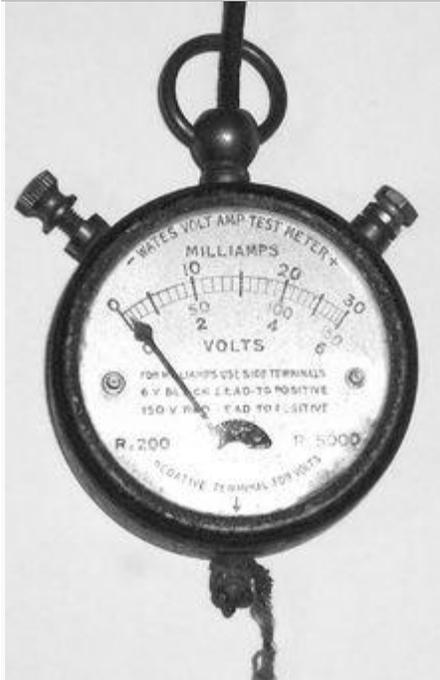
A **multimeter** or a **multitester**, also known as a **volt/ohm meter** or **VOM**, is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features such as the ability to measure voltage, current and resistance. Multimeters may use analog or digital circuits—**analog multimeters** and **digital multimeters** (often abbreviated **DMM** or **DVOM**.) Analog instruments are usually based on a microammeter whose pointer moves over a scale calibration for all the different measurements that can be made; digital instruments usually display digits, but may display a bar of a length proportional to the quantity measured.

A multimeter can be a hand-held device useful for basic fault finding and field service work or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems.

Multimeters are available in a wide range of features and prices. Cheap multimeters can cost less than US\$10, while the top of the line multimeters.

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History





The first moving-pointer current-detecting device was the galvanometer. These were used to measure resistance and voltage by using a Wheatstone bridge, and comparing the unknown quantity to a reference voltage or resistance. While useful in the lab, the devices were very slow and impractical in the field. These galvanometers were bulky and delicate.

The D'Arsonval/Weston meter movement used a fine metal spring to give proportional measurement rather than just detection, and built-in permanent field magnets made deflection independent of the 3D orientation of the meter. These features enabled dispensing with Wheatstone bridges, and made measurement quick and easy. By adding a series or shunt resistor, more than one range of voltage or current could be measured with one movement.

Multimeters were invented in the early 1920s as radio receivers and other vacuum tube electronic devices became more common. The invention of the first multimeter is attributed to United States Post Office (USPS) engineer, Donald Macadie, who became dissatisfied with having to carry many separate instruments required for the maintenance of the telecommunications circuits.<sup>[1]</sup> Macadie invented an instrument which could measure amperes (aka amps), volts and ohms, so the multifunctional meter was then named Avometer.<sup>[2]</sup> The meter comprised a moving coil meter, voltage and precision resistors, and switches and sockets to select the range.

Macadie took his idea to the Automatic Coil Winder and Electrical Equipment Company (ACWEEC, founded in ~1923).<sup>[2]</sup> The first AVO was put on sale in 1923, and although it was initially a DC. Many of its features remained almost unaltered through to the last Model 8.

Pocket watch style meters were in widespread use in the 1920s, at much lower cost than Avometers. The metal case was normally connected to the negative connection, an arrangement that caused numerous electric shocks. The technical specifications of these devices were often crude, for example the one illustrated has a resistance of just 33 ohms per volt, a non-linear scale and no zero adjustment.

The usual analog multimeter when used for voltage measurements loads the circuit under test to some extent (a microammeter with full-scale current of 50ampere, the highest sensitivity commonly available, must draw at least 50 milliamps from the circuit under test to deflect fully). This may load a high-impedance circuit so much as to perturb the circuit, and also to give a low reading.

Vacuum Tube Voltmeters or valve voltmeters (VTVM, VVM) were used for voltage measurements in electronic circuits where high impedance was necessary. The VTVM had a fixed input impedance of typically 1 megohm or more, usually through use of a cathode follower input circuit, and thus did not significantly load the circuit being tested. Before the introduction of digital electronic high-impedance analog transistor and field effect transistor (FETs) voltmeters were used. Modern digital meters and some modern analog meters use electronic input circuitry to achieve high-input impedance—their voltage ranges are functionally equivalent to VTVMs.

Additional scales such as decibels, and functions such as capacitance, transistor gain, frequency, duty cycle, display hold, and buzzers which sound when the measured resistance is small have been included on many multimeters. While multimeters may be supplemented by more specialized equipment in a technician's toolkit, some modern multimeters

include even more additional functions for specialized applications (e.g., temperature with a thermocouple probe, inductance, connectivity to a computer, speaking measured value, etc.).

Quantities measured

Contemporary multimeters can measure many quantities.

The common ones are:

- Voltage, alternating and direct, in volts.
- Current, alternating and direct, in amperes.

The frequency range for which AC measurements are accurate must be specified.

- Resistance in ohms.

Additionally, some multimeters measure:

- Capacitance in farads.
- Conductance in siemens.
- Decibels.
- Duty cycle as a percentage.
- Frequency in hertz.
- Inductance in henrys.
- Temperature in degrees Celsius or Fahrenheit, with an appropriate temperature test probe, often a thermocouple

Digital multimeters may also include circuits for:

- Continuity; beeps when a circuit conducts.
- Diodes (measuring forward drop of diode junctions, i.e., diodes and transistor junctions) and transistors (measuring current gain and other parameters).
- Battery checking for simple 1.5 volt and 9 volt batteries. This is a current loaded voltage scale. Battery checking (ignoring internal resistance, which increases as the battery is depleted), is less accurate when using a DC voltage scale.

Various sensors can be attached to multimeters to take measurements such as:

- Light level
- Acidity/Alkalinity(pH)
- Wind speed
- Relative humidity