



Electronic circuits performance evaluation using test equipment

Introduction to current and voltage consumption measurement and use of appropriate equipment

Metrology is the science of measurement and its applications, covering all the theoretical and practical aspects, according to the International Metrology Vocabulary (VIM)*

According to INMETRO (the Brazilian national institute of metrology standardization and industrial quality) metrology is an essential tool for:

- Assess the compatibility of products and processes;
- Guarantee of fair exchange relations (commercial relationships);
- Promote citizenship (health, safety, and environment);
- Quality, innovation and competitivity;
- Ensure national and international recognition.





What are the areas of Metrology?

According to INMETRO metrology is divided into three major areas:

- Scientific Metrology: that uses laboratory instruments, scientific research and methodologies based on national and international measurement standards to achieve high levels of quality.
- Industrial Metrology: whose measurement systems control industrial production processes and are responsible for the quality assurance of final products.
- Legal Metrology: which is related to measurement systems used in the areas of health, safety, and the environment.

In electrical measurement the most important measurement units are:

- Electric current;
- Electric voltage;
- Frequency;
- Power;
- Resistance;
- Capacitance;
- Inductance;



• Power factor.

Analog and Digital Parameters

Electronic circuits can be divided into two main categories, digital and analog. Digital electronics involve variables with discrete values, and analog electronics involve variables with continuous values.



Image 01: Example of Analog and Digital Signals. Source: Adapted from Newton C. Braga, Computação Analógica).

Analog Measurement Instruments





Currently, analog equipment is used in switchboards, where the electrical parameters to be analyzed do not present large instantaneous variations (they don't change rapidly) and the intended reading doesn't require great accuracy.

Some electrical panels still have fixed analog scales with labels, as pictured below, and it is also possible to find analog voltage, current, and resistance monitors called multimeters or analog multi-testers.



Image 02: Analog Industrial Panel (left) and analog multimeter (right). Source: The author.

Digital Measurement Instruments





Unlike analog measuring instruments, digital measuring instruments use digital systems to calculate measurements and analog-to-digital converters (ADCs) to deliver the electrical values to the digital system.

The digital measuring instrument most commonly used by electronic technicians and engineers is the digital multimeter (DMM) capable of measuring several parameters by easily changing its scale. In addition, the indicator is made of a liquid crystal display (LCD) that shows the measured values in digits.

Digital multimeters usually have a selector switch to change Voltage (V), Current (A), and Resistance (Ω) scales. Some models have other measurements such as capacitance (F) and diode measurement (P-N).



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Image 03: Digital Multimeter. Source: The author.





Basic Multimeter Measurements

To make any measurement with the multimeter it's necessary to make the correct connections in the terminal and use the test leads with its color corresponding to the correct terminal i.e. Voltage (V), Current (A) or Resistance (Ω) use the Red Test lead, and for the Ground (GND) or (COM) use the Black Test lead.



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Image 04: Multimeter Terminals. Source: The author.





Direct Voltage Measurements (VDC)

These are measurements used to check the level of direct voltage (VDC) that can be found in a number of different battery types, DC power supplies and bias circuits in electronic boards. In order to do this measurement, always use the red test lead in the positive terminal where you want to measure (+) and the black test lead in the negative terminal (-) or ground, use the dial in the VDC position and use a scale always with a value above that you want to measure. Let's use an example of a common 1.5V household battery so you will use a higher value depending on the multimeter, for example 20V.





Image 05: Measuring a 1.5V battery. Source: The author.

Alternating Voltage Measurements (VAC)





In AC voltage measurements such as 127Vac or 220Vac in power outlets, the selector switch is used in the (VAC) position and the scale is also higher than the measured value, the example below shows a measurement of a power outlet line filter (AC).





Image 06: Demonstration of measurement of a 127Vac Line Filter. Source: *The author*.

Direct Current (ADC) or Alternating Current (AAC) measurement



For Current measurements you must first change the position of the Current terminal, which usually has values of 10A or 20A. Set the selector switch to DCA, ADC or A, the ways to measure are always in series with the circuit which means passing the current through the multimeter as illustrated below.



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Image 07: Current measurement. Source: The author.

Resistance Measurement (Ohms) or (Ω)



In electrical resistance measurements such as a resistor or electric shower resistance, set the selector switch to the (Ω) position, and scale corresponding to a value larger than the measured value, as for the terminals and the position of the test probes is similar to DC voltage measurements.



HOLD MIN MAX RANGE

Ω



Image 08: Resistance Measurement. Source: *The author*.





Other Digital Multimeters (DMM)

- Benchtop Multimeter

A multimeter used on test benches is usually more robust and with higher capacity and precision. It is connected to the electric power (127/220Vac) outlet, but it works the same as the basic multimeter shown before (handheld multimeter).



Image 09: Benchtop Multimeter. Source: Amazon.com.



- Multimeter Pliers

The main function of the multimeter pliers is to measure alternating and direct currents, without having to open the measured circuit. In order to do that it has a clamp that measures the electric current through an electromagnetic field.



Image 10: Multimeter pliers.





Source: https://nortel.com.br/wp-content/uploads/2021/11/alicate-amperimetro.jpg





Additional reading

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