Digital Multimeter Reference Guide

Glossary of Terms

Digital Multimeter (DMM):

An electronic testing device that is used to determine specific information about the current, resistance and voltage of electrical signals travelling through a line. A digital multimeter is differentiated from an analog multimeter by the display and accuracy of the device. Analog multimeters use a less-accurate needle and gauge to display results, whereas a digital multimeter converts the signals into a digital format that is shown on an LED display. A DMM is useful in resolving electrical problems in many types of equipment, ranging from automobiles to mobile electronics.

Accuracy:

The precision of the DMM's displayed measurements compared to the actual value of the signal being measured. This is expressed as a percentage of reading.

AC & DC Voltage/Current Measurements:

A DMM can measure the voltage of both alternating current (AC) and direct current (DC). Most generated electricity is AC, whereas most stored electricity is DC. However, electricity at certain voltages is both AC and DC.

Auto-ranging:

One useful function that is available, typically on higher end digital multimeters is the auto-range capability. This capability enables the DMM to select the right range automatically. You only need to select DC / AC and Amps / Volts / Ohms, etc. and the meter will do the rest. This can be a very useful capability when undertaking a lot of measurements. When holding onto two probes, it can become awkward because at times it can be difficult to let one go to alter the range and then recontact probes to measuring points.

Autopolarity:

This function displays a negative reading with a minus sign that indicates you connected the leads in reverse. However, this will not cause damage to the meter.

Average-responding DMM:

A DMM that accurately measures sinusoidal waveforms, while measuring non-sinusoidal waveforms with less accuracy.

Category Rating:

CAT ratings on a meter indicate the maximum voltage a meter can be used in a "geographic" area of the electrical system. IEC-1010-1 specifies categories of overvoltage based on the distance from the power source and the natural damping of transient energy that occurs in an electrical distribution system. Higher categories are closer to the power source and require more protection. Within each installation category there are voltage classifications. It is the combination of installation category and voltage classification which determines the maximum transient withstanding capabilities of the instrument. Categories are divided into four different groups:

- CAT I: Electronic and other equipment after the main transformer.
- CAT II: Anything connected to normal household outlets.
- CAT III: Industrial and other high current installations. Electric battery bus systems *may* fall under this category.
- CAT IV: Distribution and outdoor conductors.

Clamp Meter:

Clamp Meter allows users to simply clamp around wire, cables, and other conductors at any point in the electric system and measure its current, without disconnecting it. There are two types:

- A transformer–type clamp meter that scales down the clamp being measured. The DMM displays 1mk for every amp being measured.
- A Hall–Effect clamp meter that measures AC or DC high current by scaling down the current and converting this reduced current to a voltage. The DMM displays 1mV for every amp.

Conductance:

Conductance is a measurement of how easily an electrical signal can be transmitted through a specific medium. Conductance is measured by the standard unit known as siemens, which is the equivalent of 1 ampere per volt.

Continuity Check:

A continuity check is one of the basic tests that can be performed with a DMM. Continuity determines whether an electrical circuit is open or closed. A closed circuit is one in which an electrical signal may be transmitted, whereas an open circuit is one that is broken or blocked, impeding the signal. A circuit that does not check out as having continuity may often be fixed by replacing a broken or disconnected wire.

Diode Check:

Diodes are connected to an electrical circuit to ensure that electricity flows in only one direction through the circuit. A diode check can reveal if a diode is malfunctioning by conducting electricity in the opposite direction. It can also discover the voltage loss experienced by electricity as it passes through the diode.

Display Count:

The display count of a DMM refers to how large or how accurate a measurement can be taken and shown on the LED display. Display count is stated in terms of x00. The x is a whole number that represents the maximum top digit before a unit of precision is lost. For instance, a 2000 display count has four total digits that will measure voltage up to 1999. At 20 volts, the precision drops, so the display would read 020.0.

Display Digits:

Display digits are the number of digits the display of a DMM will show. Half digits mean only a 1 or 0 will be displayed as the final digit.

Hold Function:

The hold function stops the DMM from making a new reading while freezing the currently displayed value.

Min/Max Function:

The min/max function of a DMM records the lowest and highest readings taken since the function was started.

Frequency, Period, Duty Cycle Measurements

Many DMMs can measure more than current, resistance and voltage. Frequency is a measurement of the number of cycles of the electrical signal, expressed in hertz. Period refers to the time it takes for the signal to complete one cycle. Duty cycle is the ratio of electrical pulses to the duration of the pulses, which is equivalent to the ratio of average power to peak power.

Loading Effect:

Meters used to measure voltage or current have an internal resistance. Since the meter must be connected to the circuit to make a measurement, the circuit can be affected by the resistance of the meter. In most cases, the internal resistance of a voltmeter (10MΩ) and a current meter (0Ω) is insignificant.

Ohm's Law:

An equation that explains the relationship between voltage, current and resistance. DMM measurements can illustrate the relationship between voltage, current and resistance [see Figure 1].

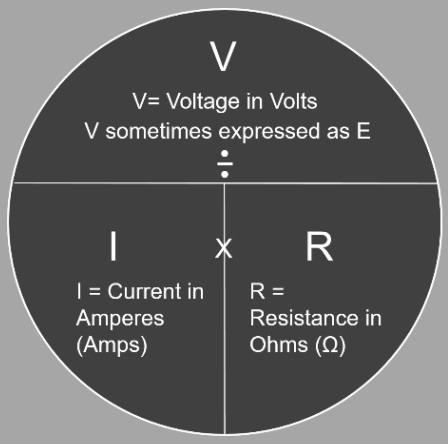


Figure 4

Place your finger over the unknown value to determine whether to multiply or divide to solve for the unknown.

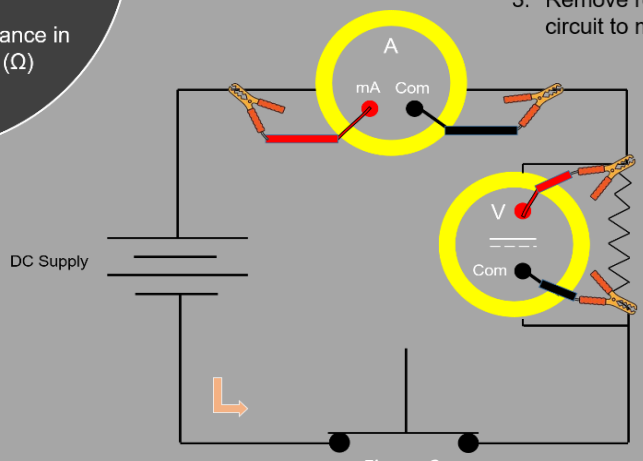


Figure 2

To measure resistance:

1. Open switch
2. Measure voltage across resistor [verify power has been removed]
3. Remove resistor from circuit to measure value

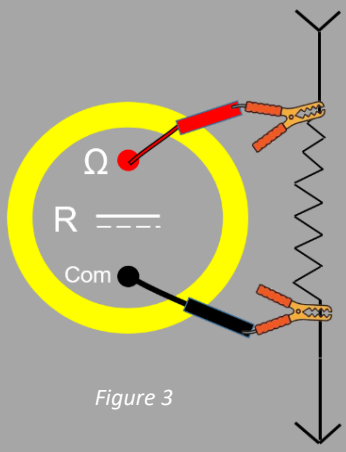


Figure 3

Overload Protection:

Overload protection prevents damage to the meter and the circuit while protecting the user.

Relative Mode (REL):

Stores existing reading (a delta) and resets display to zero. Sets a relative reference point to measure against the next reading.

Temperature Measurements, J-Type/K-Type:

Temperature can be measured by some DMMs through the use of a thermocouple. J-type thermocouples measure lower temperatures than do K-type thermocouples. J-type thermocouples only measure temperatures up to 600° C, while K-type thermocouples measure temperatures up to 1,273° C.

Resolution:

Resolution is the level of detail that is quantifiable on a DMM. The higher the number of DMM display digits, the higher the resolution of the DMM. [See Figure 2]

TRMS Responding DMM:

TRMS stands for true root mean squared. TRMS multimeters apply a compensating factor that accounts for distortion to achieve a more accurate reading.

Voltage/Current Measurement Accuracy:

The voltage and current measurements taken by a DMM are not always totally accurate. The potential for variation is given in the specific device's accuracy rating, which is usually around 0.5 percent.

Figure 1

Safety Precautions

Safety Rating:

When measuring voltages, particularly on electrical installations it is necessary to ensure that the digital multimeter has an adequate safety rating. IEC 1010 categorizes meters according to their safety ratings. These not only take into account the working voltage, but also the resilience to peak transients that often occur on the lines. It is necessary to ensure that any meter being used for these applications is suitably rated. This may result in needing to buy a more expensive meter.

These specifications and certifications are normally only available for the top DMMs. Companies who produce DMMs to these specifications need to have them tested and this costs time and money. The low end DMMs for occasional use are imports and neither the manufacturers nor importers are generally set up to gain these certifications, and also it would not be financially viable for them.

Safety ratings are required for applications where the engineers are working on high voltages and it is essential that the meter is guaranteed to be safe under all conditions. For normal occasional use, these ratings are normally not considered to be necessary.

It is worth considering whether it is a requirement when buying digital multimeter. This capability is particularly useful for applications like field service where it may not be convenient to keep selecting a range to obtain the optimum reading. Unfortunately, this capability tends to come with the much higher priced DMMs, so it is worth considering whether this capability is worthwhile when buying the DMM.

User Errors:

- Wrong settings (i.e., ohms scale selected when testing voltage)
- Wrong value of DMM replacement fuse installed
- Wrong “CAT” area application
- Wrong probe socket used (i.e., amps instead of volts)
- Wrong use of the product, such as switching settings under power
- Wrong voltage applied, exceeding limits of meter
- Adding to the user error problem is wear, tear and contamination within the meter that creates internal component failures or compromises the components’ dielectric properties. Still other causes concluded that because of complicated markings on the meter, many users have no idea what a “CAT” rating is, let alone the fact that using a CAT II meter in a CAT III area can lead to their catastrophic failure.

CAT RATINGS:

Category	Voltage	Transient Voltage	Impedance (Ohms)
CAT 1	150	800	30
CAT 1	300	1500	30
CAT 1	600	2500	30
CAT 1	1000	4000	30

Category	Voltage	Transient Voltage	Impedance (Ohms)
CAT III	150	2500	2
CAT III	300	4000	2
CAT III	600	6000	2
CAT III	1000	8000	2

Category	Voltage	Transient Voltage	Impedance (Ohms)
CAT II	150	1500	12
CAT II	300	2500	12
CAT II	600	4000	12
CAT II	1000	6000	12

Category	Voltage	Transient Voltage	Impedance (Ohms)
CAT IV	150	4000	2
CAT IV	300	6000	2
CAT IV	600	8000	2
CAT IV	1000	12000	2

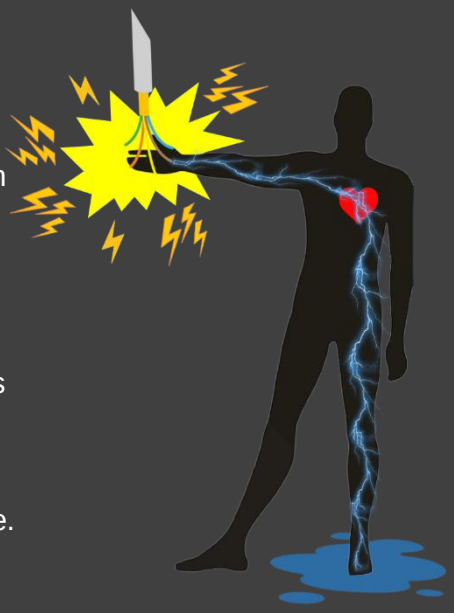
DMM Safety Tips:

- Never apply power to the circuit when measuring resistance with a multimeter
- DO NOT use your test leads if the protective insulation on the leads or probes is cracked or worn. Your fingers may touch the probe conductor which may result in a very bad shock.
- Make sure leads and probes match the DMM Category Rating
- Inspect your DMM before usage. DO NOT assume the multimeter is in a good working condition. You should check if it functions properly before you work on a high-energy live circuit. Use a proving unit or a known voltage source.
- Be sure that the multimeter is switched to AC prior to trying to measure AC circuits.
- In case you want to verify the presence of dangerous voltage in a circuit with a digital multimeter, it is crucial to verify both ac and dc voltage.
- Set the ideal current range before measuring higher current or else it will blow the digital multimeter fuse.
- A resistor should be measured standalone or the connected parts in the circuit may affect the reading.
- If there is a capacitor in the circuit, you will definitely hear a beep sound until the capacitor drains. Constantly confirm the presence of the capacitor to prevent any confusion.

Avoiding Electric Shock:

Electric shock happens when the body of the operator becomes part of an electrical circuit. For this reason, you should always assume that all the component of an electrical circuit is energized. To avoid electric shock, follow the tips below:

- You should also be aware of the positioning of your body when you find yourself in electrical environments.
- You should perform energize electrical work following the quote, “One Hand Rule.” This requires the individual to place one hand in a pocket to prevent contact with grounded work surfaces while performing energize electrical work. This will prevent electronical current from flowing through the heart.
- Make use of your personal protective materials. Wear your gloves, and headwear, and use the insulated rubber mats when working near energized or on electrical circuits that are 50 V or greater.
- Review equipment manual and drawings to note safety cautions and warnings. Caution and Warning Notices indicates a potentially hazardous condition. Caution Notice indicate, if not avoided it can lead to minor or moderate injury. Warning Notice indicate, if not avoided it can lead to death or major injury.
- When working near or on energized or exposed circuit, do not work alone.
- Avoid operating the meter in damp or humid environments.
- Watch for the audio or visual warnings in your multimeter display unit.
- Know the CAT rating of your DMM.



Current (mA)	Effects on the Body
1 or less	No sensation; probably not noticed
1 – 3	Mild sensation not painful
3 – 10	Painful shock
10 – 30	Muscular control could be lost or muscle clamping
30 – 75	Respiratory paralysis
75 mA – 4 A	Ventricular Fibrillation
Over 4 A	Tissue begins to burn. Heart muscles clamp and heart stops beating.

Effects of Electrical Current on the Human Body

Understanding the Dangers:

The seriousness of an electric shock depends on:

- The amount of current flowing through the circuit
- How long the body is exposed to the flow of current
- The area exposed to the contact and the path through which the current flows
- The condition of the exposed region to the current (for instance, dry hands have more resistance to current flow than wet hands).

Transient overvoltage (power surge):

This is a brief, unwanted, erratic spike in energy that can amount up to thousands of volts. Lightning strikes, switching power on and off, motors and unfiltered electrical equipment are the prime generators of spikes. Transient overvoltage is an almost inevitable danger of testing electrical equipment.

Arc blasts, arc flashes*:

These are the current discharge across an air gap. They are caused by:

a) accidental contact between conductors or

b) excess voltage ionizing the air between the conductors.

*Note: Arc blast or flash can occur in an electrical system when a power line transient happens as a multimeter is used to record the voltage. CAT-rated multimeters are made to reduce, lower or forestall the occurrence of this situation within the meter.

Online DMM Resources and Tutorials:

Websites:

- Peruse “Fluke” (note: https://www.fluke.com ref. specifics
- Peruse “All About Circuits” (note: www.allaboutcircuits.com ref. specifics

Tutorials:

- Electrical Measurement Safety by Fluke (24.59 minutes)

  Electrical Measurement Safety by Fluke
- View How to use a Digital Multimeter for Beginners – How to Measure Voltage, Resistance, Continuity and Amps (8.07 minutes)

  How to use a Digital Multimeter for Beginners
- How to Use a MULTIMETER – Beginner’s Guide (Measuring volts, resistance, continuity & amps) (9:29)

  How to Use a MULTIMETER -- Beginner's Guide
- View How to Use a Multimeter (10.33 minutes) How to Use a Multimeter
- View Checking for Open Circuitry using an Ohmmeter/Voltmeter (1.52/2.37 minutes) Checking for Open Circuitry using an Ohmmeter/Voltmeter