ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.6

Shock Proof Techniques & Multimeter

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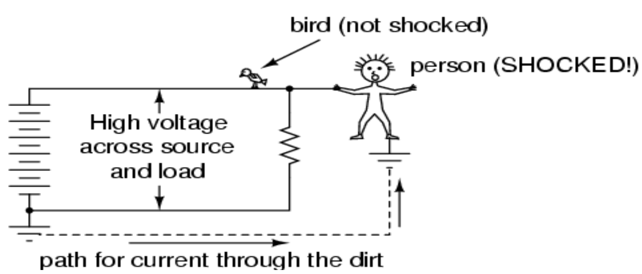
Abstract:
In this paper, we are discussing the shocks from which human suffers & its other attributes, the prevention from various shocks and a detailed description & usage of multimeter. A strong comparison is shown between bird & human and their shock absorbing capacity.

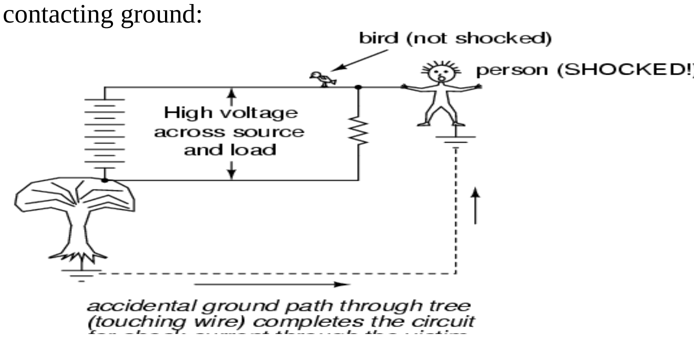
Keywords: Current, Ammeter, Multimeter, Shock, Voltage, Circuit, Voltmeter, Resistance

1. INTRODUCTION

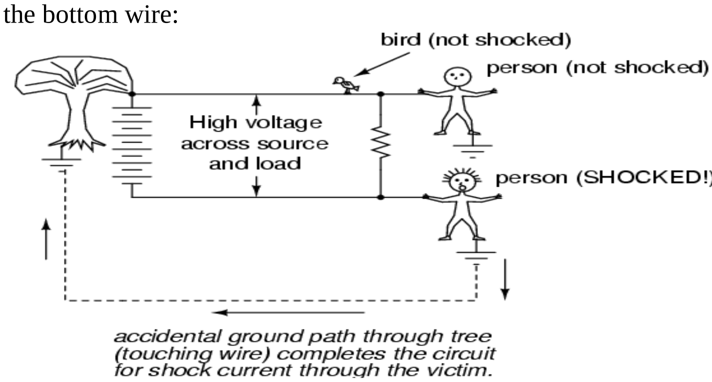
As we know, electricity requires a complete path to continuously flow. This is why the shock received from static electricity is only a momentary jolt: the flow of electrons is necessarily brief when static charges are equalized between two objects. Shocks of self-limited duration like this are rarely hazardous. Without two contact points on the body for current to enter and exit, respectively, there is no hazard of shock. This is why birds can safely rest on high-voltage power lines without getting shocked: they make contact with the circuit at only one point. In order for electrons to flow through a conductor, there must be a voltage present to motivate them. Voltage is *always relative between two points*. There is no such thing as voltage "on" or "at" a single point in the circuit, and so the bird contacting a single point in the above circuit has no voltage applied across its body to establish a current through it. Yes, even though they rest on *two* feet, both feet are touching the same wire, making them *electrically common*. Electrically speaking, both of the bird's feet touch the same point; hence there is no voltage between them to motivate current through the bird's body.



The ground symbol is that set of three horizontal bars of decreasing width located at the lower-left of the circuit shown, and also at the foot of the person being shocked. In real life the power system ground consists of some kind of metallic conductor buried deep in the ground for making maximum contact with the earth. That conductor is electrically connected to an appropriate connection point on the circuit with thick wire. The victim's ground connection is through their feet, which are touching the earth.The presence of an intentional "grounding" point in an electric circuit is intended to ensure that one side of it *is* safe to come in contact with. Note that if our victim in the above diagram were to touch the bottom side of the resistor, nothing would happen even though their feet would still be contacting ground:



Such an accidental connection between a power system conductor and the earth is called a *ground fault*. Ground faults may be caused by many things, including dirt buildup on power line insulators, ground water infiltration in buried power line conductors, and birds landing on power lines, bridging the line to the pole with their wings. Given the many causes of ground faults, they tend to be unpredictable. In the case of trees, no one can guarantee *which wire* their branches might touch. If a tree were to brush up against the top wire in the circuit, it would make the top wire safe to touch and the bottom one dangerous -- just the opposite of the previous scenario where the tree contacts the bottom wire:



With a tree branch contacting the top wire, that wire becomes the grounded conductor in the circuit, electrically common with earth ground. Therefore, there is no voltage between that wire and ground, but full voltage between the bottom wire and ground. As mentioned previously, tree branches are only one potential source of ground faults in a power system. Consider an ungrounded power system with no trees in contact, but this time with *two* people touching single wires:

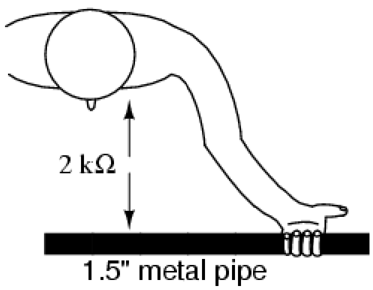
Research conducted on contact resistance between parts of the human body and points of contact shows a wide range of figures.

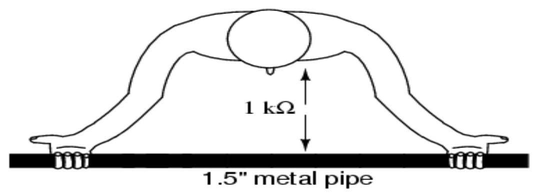
- Hand or foot contact, insulated with rubber: 20 MΩ typical.
- Foot contact through leather shoe sole (dry): 100 kΩ to 500 kΩ
- Foot contact through leather shoe sole (wet): 5 kΩ to 20 kΩ

Research has provided an approximate set of figures for electrical resistance of human contact points under different conditions:

- Wire touched by finger: 40,000 Ω to 1,000,000 Ω dry, 4,000 Ω to 15,000 Ω wet.
- Wire held by hand: 15,000 Ω to 50,000 Ω dry, 3,000 Ω to 5,000 Ω wet.
- Metal pliers held by hand: 5,000 Ω to 10,000 Ω dry, 1,000 Ω to 3,000 Ω wet.
- Contact with palm of hand: 3,000 Ω to 8,000 Ω dry, 1,000 Ω to 2,000 Ω wet.
- 1.5-inch metal pipe grasped by one hand: 1,000 Ω to 3,000 Ω dry, 500 Ω to 1,500 Ω wet.
- 1.5-inch metal pipe grasped by two hands: 500 Ω to 1,500 kΩ dry, 250 Ω to 750 Ω wet.
- Hand immersed in conductive liquid: 200 Ω to 500 Ω.
- Foot immersed in conductive liquid: 100 Ω to 300 Ω.

Note the resistance values of the two conditions involving a 1.5-inch metal pipe. The resistance measured with two hands grasping the pipe is exactly one-half the resistance of one hand grasping the pipe.





Two 2 kΩ contact points in "parallel" with each other gives 1 kΩ total pipe-to-body resistance.

With two hands, the bodily contact area is twice as great as with one hand. This is an important lesson to learn: electrical resistance between any contacting objects diminishes with increased contact area, all other factors being equal. With two hands holding the pipe, electrons have two, *parallel* routes through which to flow from the pipe to the body. In industry, 30 volts is generally considered to be a conservative threshold value for dangerous voltage. The cautious person should regard any voltage above 30 volts as threatening, not relying on normal body resistance for protection against shock. That being said, it is still an excellent idea to keep one's hands clean and dry, and remove all metal jewelry when working around electricity. Even around lower voltages, metal jewelry can present a hazard by conducting enough current to burn the skin if brought into contact between two points in a circuit. Metal rings, especially, have been the cause of more than a few burnt fingers by bridging between points in a low-voltage, high-current circuit. The best protection against shock from a live circuit is resistance, and resistance can be added to the body through the use of insulated tools, gloves, boots, and other gear. Current in a circuit is a function of available voltage divided by the *total* resistance in the path of the flow. As we will investigate in greater detail later in this book, resistances have an additive effect when they're stacked up so that there's only one path for electrons to flow:

Person in direct contact with voltage source:
current limited only by body resistance.

$$I = \frac{E}{R_{body}}$$

Person wearing insulating gloves and boots:
current now limited by *total* circuit resistance.

$$I = \frac{E}{R_{glove} + R_{body} + R_{boot}}$$

Because electric current must pass through the boot *and* the body *and* the glove to complete its circuit back to the battery, the combined total of these resistances opposes the flow of electrons to a greater degree than any of the resistances considered individually. Safety is one of the reasons electrical wires are usually covered with plastic or rubber insulation: to vastly increase the amount of resistance between the conductor and whoever or whatever might contact it. Unfortunately, it would be prohibitively expensive to enclose power line conductors in sufficient insulation to provide safety in case of accidental contact, so safety is maintained by keeping those lines far enough out of reach so that no one can accidently touch them.

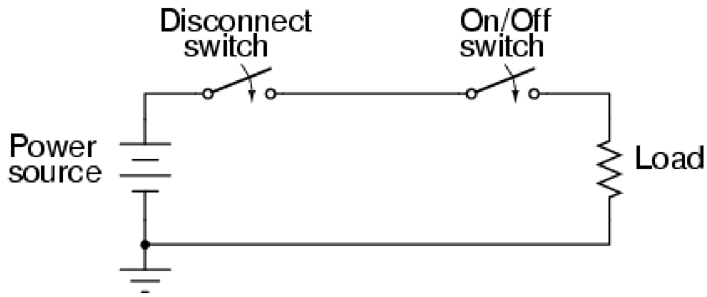
2. SAFETY PRACTICES

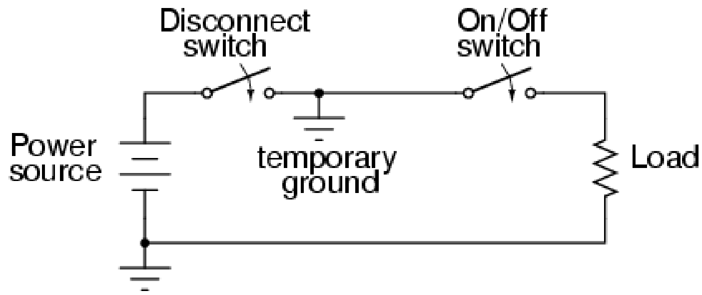
If at all possible, shut off the power to a circuit before performing any work on it. You must secure all sources of harmful energy before a system may be considered safe to work on. In industry, securing a circuit, device, or system in this condition is commonly known as placing it in a *Zero Energy State*. The focus of is, of course, electrical safety. Securing something in a Zero Energy State means ridding it of any sort of potential or stored energy, including but not limited to:

- Dangerous voltage
- Spring pressure
- Hydraulic (liquid) pressure
- Pneumatic (air) pressure
- Suspended weight

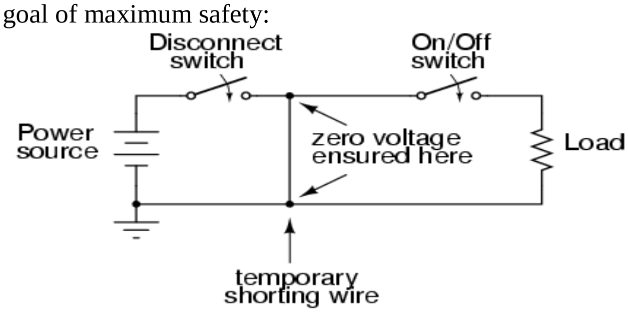
- Chemical energy (flammable or otherwise reactive substances)
- Nuclear energy (radioactive or fissile substances)

All properly designed circuits have "disconnect" switch mechanisms for securing voltage from a circuit. Sometimes these "disconnects" serve a dual purpose of automatically opening under excessive current conditions, in which case we call them "circuit breakers." Other times, the disconnecting switches are strictly manually-operated devices with no automatic function. In either case, they are there for your protection and must be used properly. Please note that the disconnect device should be separate from the regular switch used to turn the device on and off. It is a safety switch, to be used only for securing the system in a Zero Energy State:





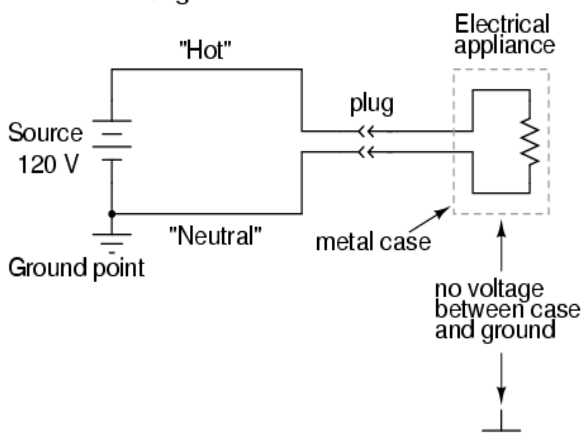
With the disconnect switch in the "open" position as shown, the circuit is broken and no current will exist. There will be zero voltage across the load, and the full voltage of the source will be dropped across the open contacts of the disconnect switch. Note how there is no need for a disconnect switch in the lower conductor of the circuit. Because that side of the circuit is firmly connected to the earth, it is electrically common with the earth and is best left that way. For maximum safety of personnel working on the load of this circuit, a temporary ground connection could be established on the top side of the load, to ensure that no voltage could ever be dropped across the load: With the temporary ground connection in place, both sides of the load wiring are connected to ground, securing a Zero Energy State at the load. Since a ground connection made on both sides of the load is electrically equivalent to short-circuiting across the load with a wire, that is another way of accomplishing the same goal of maximum safety:

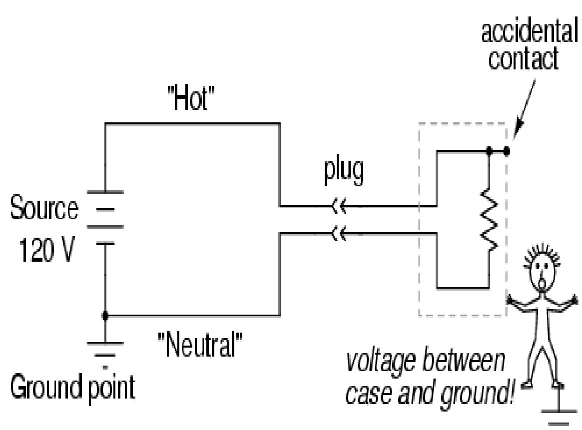


Either way, both sides of the load will be electrically common to the earth, allowing for no voltage between either side of the load and the ground people stand on. This technique of temporarily grounding conductors in a de-energized power system is very common in maintenance work performed on high voltage power distribution systems.

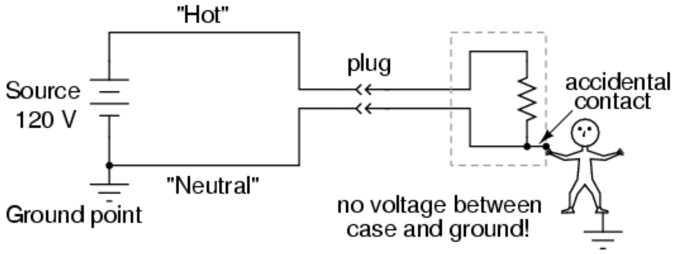
3. SAFECIRCUIT DESIGN

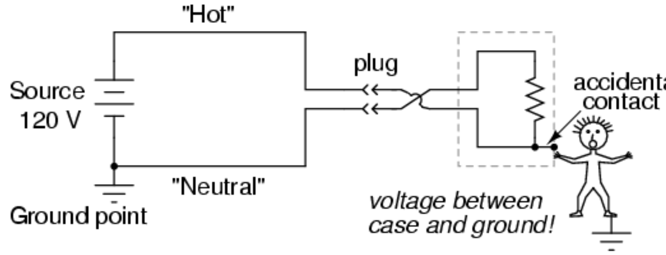
By grounding one side of the power system's voltage source, at least one point in the circuit can be assured to be electrically common with the earth and therefore present no shock hazard. In a simple two-wire electrical power system, the conductor connected to ground is called the *neutral*, and the other conductor is called the *hot*, also known as the *live* or the *active*. This imbalance of hazard between the two conductors in a simple power circuit is important to understand. The following series of illustrations are based on common household wiring systems. If we take a look at a simple, household electrical appliance such as a toaster with a conductive metal case, we can see that there should be no shock hazard when it is operating properly. The wires conducting power to the toaster's heating element are insulated from touching the metal case by rubber or plastic.



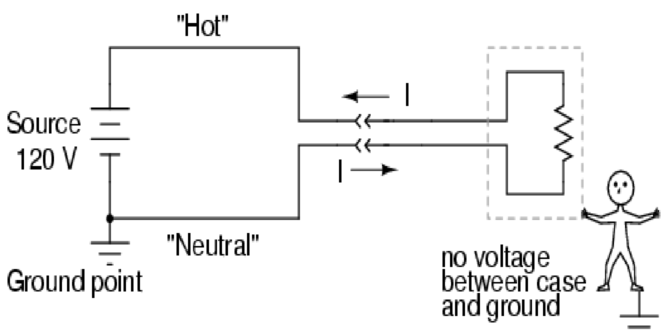


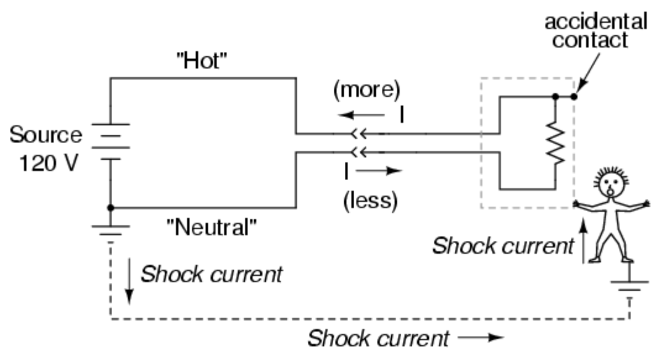
However, if one of the wires inside the toaster were to accidently come in contact with the metal case, the case will be made electrically common to the wire, and touching the case will be just as hazardous as touching the wire bare. Whether or not this presents a shock hazard depends on *which* wire accidentally touches. If the "hot" wire contacts the case, it places the user of the toaster in danger. On the other hand, if the neutral wire contacts the case, there is no danger of shock:



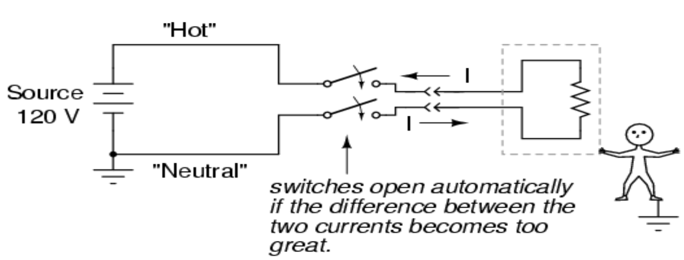


To help ensure that the former failure is less likely than the latter, engineers try to design appliances in such a way as to minimize hot conductor contact with the case. Ideally, of course, you don't want either wire accidently coming in contact with the conductive case of the appliance, but there are usually ways to design the layout of the parts to make accidental contact less likely for one wire than for the other. However, this preventative measure is effective only if power plug polarity can be guaranteed. If the plug can be reversed, then the conductor more likely to contact the case might very well be the "hot" one: Appliances designed this way usually come with "polarized" plugs, one prong of the plug being slightly narrower than the other. Power receptacles are also designed like this, one slot being narrower than the other. Consequently, the plug cannot be inserted "backwards," and conductor identity inside the appliance can be guaranteed. Remember that this has no effect whatsoever on the basic function of the appliance: it's strictly for the sake of user safety. Some engineers tackle the problem of safety by maintaining a conductive case, but using a third conductor to firmly connect that case to ground: The third prong on the power cord provides a direct electrical connection from the appliance case to earth ground, making the two points electrically common with each other. If they're electrically common, then there cannot be any voltage dropped between them. At least, that's how it is supposed to work. If the hot conductor accidently touches the metal appliance case, it will create a direct short-circuit back to the voltage source through the ground wire, tripping any overcurrent protection devices. The user of the appliance will remain safe. Electrically safe engineering doesn't necessarily end at the load, however. A final safeguard against electrical shock can be arranged on the power supply side of the circuit rather than the appliance itself. This safeguard is called *ground-fault detection*, and it works like this:





In a properly functioning appliance, the current measured through the hot conductor should be exactly equal to the current through the neutral conductor, because there's only one path for electrons to flow in the circuit. With no fault inside the appliance, there is no connection between circuit conductors and the person touching the case, and therefore no shock. This difference in current between the "hot" and "neutral" conductors will only exist if there is current through the ground connection, meaning that there is a fault in the system. Therefore, such a current difference can be used as a way to *detect* a fault condition. If a device is set up to measure this difference of current between the two power conductors, a detection of current imbalance can be used to trigger the opening of a disconnect switch, thus cutting power off and preventing serious shock:

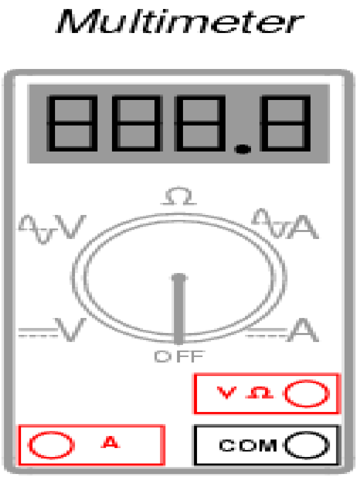


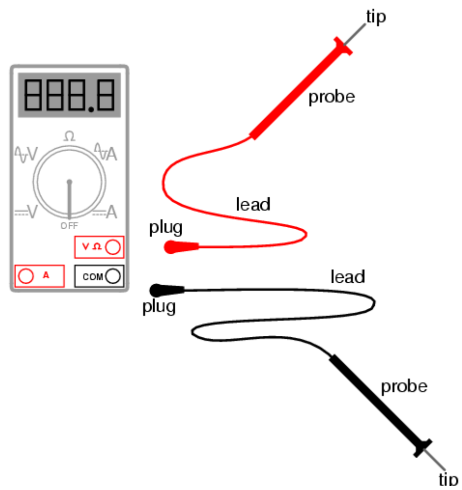
Such devices are called *Ground Fault Current Interrupters*, or GFCIs for short. Outside North America, the GFCI is variously known as a safety switch, a residual current device (RCD), an RCBO or RCD/MCB if combined with a miniature circuit breaker, or earth leakage circuit breaker (ELCB). They are compact enough to be built into a power receptacle. These receptacles are easily identified by their distinctive "Test" and "Reset" buttons. The big advantage with using this approach to ensure safety is that it works regardless of the appliance's design. The *arc fault circuit interrupter (AFCI)*, a circuit breaker designed to prevent fires, is designed to open on intermittent resistive short circuits. For example, a normal 15 A breaker is designed to open circuit quickly if loaded well beyond the 15 A rating, more slowly a little beyond the rating. While this protects against direct shorts and several seconds of overload, respectively, it does not protect against arcs– similar to arc-welding.

An arc is a highly variable load, repetitively peaking at over 70 A, open circuiting with alternating current zero-crossings. Though, the average current is not enough to trip a standard breaker, it is enough to start a fire. This arc could be created by a metalic short circuit which burns the metal open, leaving a resistive sputtering plasma of ionized gases.

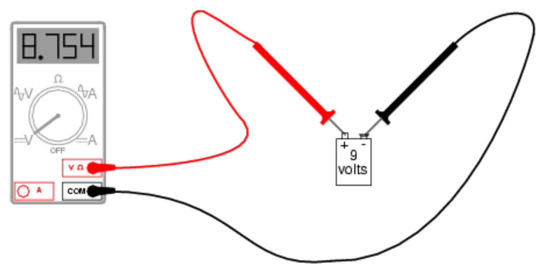
4. SAFE METER USAGE

The most common piece of electrical test equipment is a meter called the *multimeter*. Multimeters are so named because they have the ability to measure a multiple of variables: voltage, current, resistance, and often many others, some of which cannot be explained here due to their complexity. In the hands of a trained technician, the multimeter is both an efficient work tool and a safety device. In the hands of someone ignorant and/or careless, however, the multimeter may become a source of danger when connected to a "live" circuit.There are many different brands of multimeters, with multiple models made by each manufacturer sporting different sets of features. The multimeter shown here in the following illustrations is a "generic" design, not specific to any manufacturer, but general enough to teach the basic principles

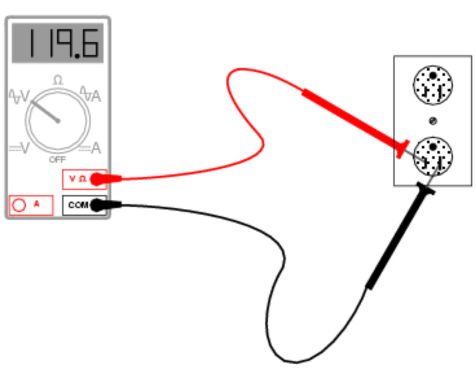


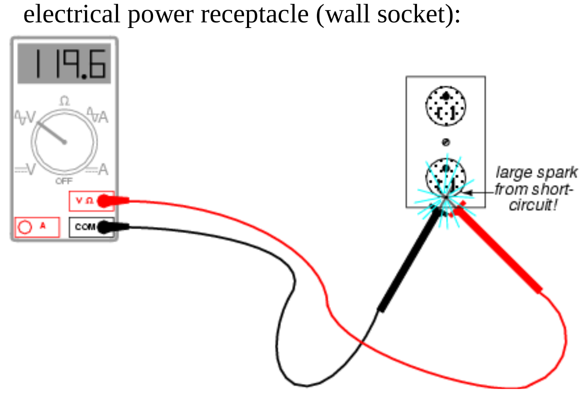


The rotary selector switch has five different measurement positions it can be set in: two "V" settings, two "A" settings, and one setting in the middle with a funny-looking "horseshoe" symbol on it representing "resistance." The "horseshoe" symbol is the Greek letter "Omega" (Ω), which is the common symbol for the electrical unit of ohms.There are three different sockets on the multimeter face into which we can plug our *test leads*. Test leads are nothing more than specially-prepared wires used to connect the meter to the circuit under test. The wires are coated in a color-coded flexible insulation to prevent the user's hands from contacting the bare conductors, and the tips of the probes are sharp, stiff pieces of wire. The black test lead *always* plugs into the black socket on the multimeter: the one marked "COM" for "common." The red test lead plugs into either the red socket marked for voltage and resistance, or the red socket marked for current, depending on which quantity you intend to measure with the multimeter.

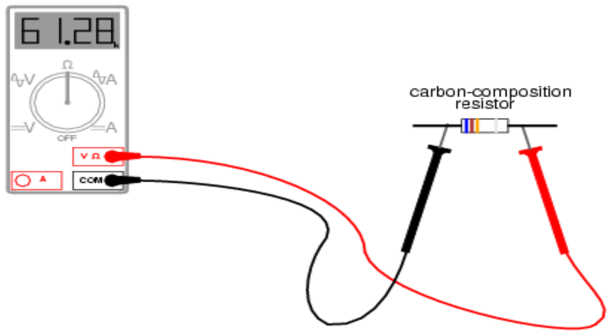


Note that the two test leads are plugged into the appropriate sockets on the meter for voltage, and the selector switch has been set for DC "V". Now, we'll take a look at an example of using the multimeter to measure AC voltage from a household electrical power receptacle (wall socket):

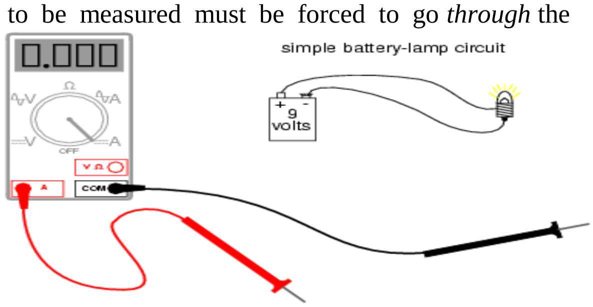




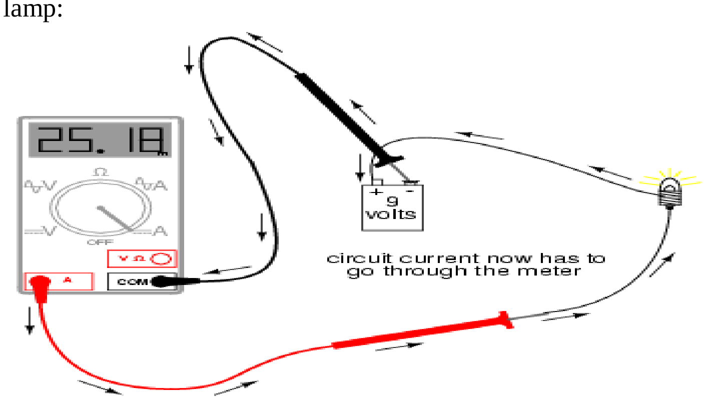
The only difference in the setup of the meter is the placement of the selector switch: it is now turned to AC "V". Since we're still measuring voltage, the test leads will remain plugged in the same sockets. In both of these examples, it is *imperative* that you not let the probe tips come in contact with one another while they are both in contact with their respective points on the circuit. If this happens, a short-circuit will be formed, creating a spark and perhaps even a ball of flame if the voltage source is capable of supplying enough current! The following image illustrates the potential for hazard. Also, it must be remembered that digital multimeters usually do a good job of discriminating between AC and DC measurements, as they are set for one or the other when checking for voltage or current. As we have seen earlier, both AC and DC voltages and currents can be deadly, so when using a multimeter as a safety check device you should always check for the presence of both AC and DC, even if you're not expecting to find both! Also, when checking for the presence of hazardous voltage.Using a multimeter to check for resistance is a much simpler task. The test leads will be kept plugged in the same sockets as for the voltage checks, but the selector switch



The "resistance" mode of a multimeter is very useful in determining wire continuity as well as making precise measurements of resistance. When there is a good, solid connection between the probe tips, the meter shows almost zero Ω. If the test leads had no resistance in them, it would read exactly zero. By far the most hazardous and complex application of the multimeter is in the measurement of current. The reason for this is quite simple: in order for the meter to measure current, the current to be measured must be forced to go *through* the

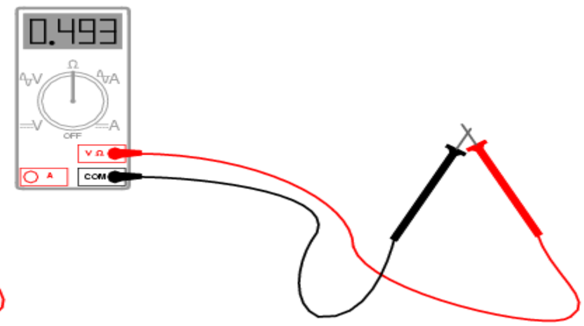


Now, the circuit is broken in preparation for the meter to be connected. The next step is to insert the meter in-line with the circuit by connecting the two probe tips to the broken ends of the circuit, the black probe to the negative (-) terminal of the 9-volt battery and the red probe to the loose wire end leading to the lamp:

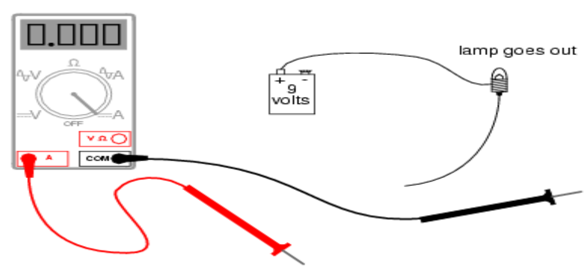


All good-quality multimeters contain fuses inside that are engineered to "blow" in the event of excessive current through them, such as in the case illustrated in the last image. Like all overcurrent protection devices, these fuses are primarily designed to *protect the equipment* from excessive damage, and only secondarily to protect the user from harm. A multimeter can be used to check its own current fuse by setting the selector switch to the resistance position and creating a connection between the two red sockets.A good fuse will indicate very little

will need to be turned until it points to the "horseshoe" resistance symbol. Touching the probes across the device whose resistance is to be measured, the meter should properly display the resistance in ohms:



meter. This means that the meter must be made part of the current path of the circuit rather than just be connected off to the side somewhere as is the case when measuring voltage. In order to make the meter part of the current path of the circuit, the original circuit must be "broken" and the meter connected across the two points of the open break. To set the meter up for this, the selector switch must point to either AC or DC "A" and the red test lead must be plugged in the red socket marked "A".



resistance while a blown fuse will always show "O.L.". The actual number of ohms displayed for a good fuse is of little consequence, so long as its an arbitrarily low figure.

7. CONCLUSION & RESULT:

The above described paper covers the subject of shock proof widely. It acknowledges the shock, its types, variations, preventions, differences in shock levels in birds & humans.It also undergoes the detailed description & usage of multimeter in electrical engineering. This paper serves as the short & effective capsule for the electrical, electronics & communication engineering students.

8. ACKNOWLEDGEMENT:

We take this opportunity to express our deep sense of gratitude & whole hearted thanks to our Institution “Technovision, Lucknow, Uttar Pradesh” for inspiring and encouraging us to explore ourselves. Our Institute has always focused on providing us a framework for better future for mankind. Also in shaping us to become effective, skilled professionals in coming future. We are very thankful to the Institute’s Management & our Director Sir for his kindness, constant encouragement, influential leadership & for the valuable time which he devoted to us. Also, thanks to our family & friends who directly & indirectly helped,

supported & motivated us along the due course of completion of this review paper.

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9.AUTHOR PROFILE

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