How to Measure the Effect of Earthing on Body Voltage

by
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In 2004, electrical engineer and electrostatic discharge expert Roger Applewhite conducted an experiment to measure voltage on a grounded and ungrounded body. For this purpose, he was both the subject and the author of the experiment, published in the journal of *European Biology and Bioelectromagnetics*.[1]

The experiment demonstrated that grounding decreases common alternating current voltage (in this case 60 Hz) induced on the body in a hotel room by a factor of about 70, a level similar to the electrical "noise" present in the room.

Mr. Applewhite took measurements on himself while ungrounded and then grounded using a conductive Earthing patch (referred to as a pain patch) and a conductive bed pad. He measured the induced voltage at three positions: left breast, abdomen, and left thigh with each grounding method. Figure 1 shows the configuration of the room where the experiment was performed.

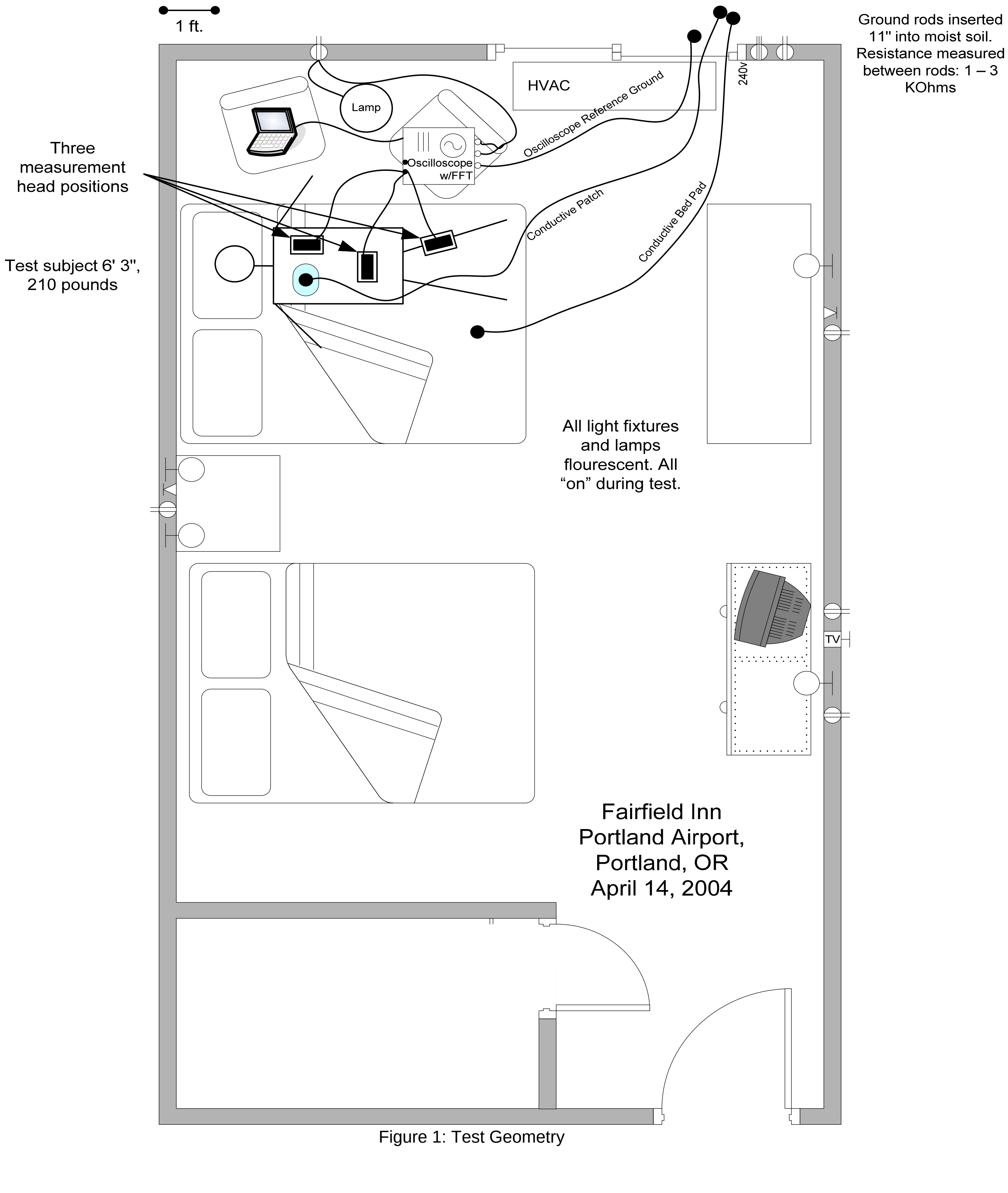


Figure 1: Test Geometry

Figure 2 shows the reduction in voltage for the conductive patch and the bed pad at each of the 3 positions on the subject's body. The results for both the patch and the bed pad are similar.

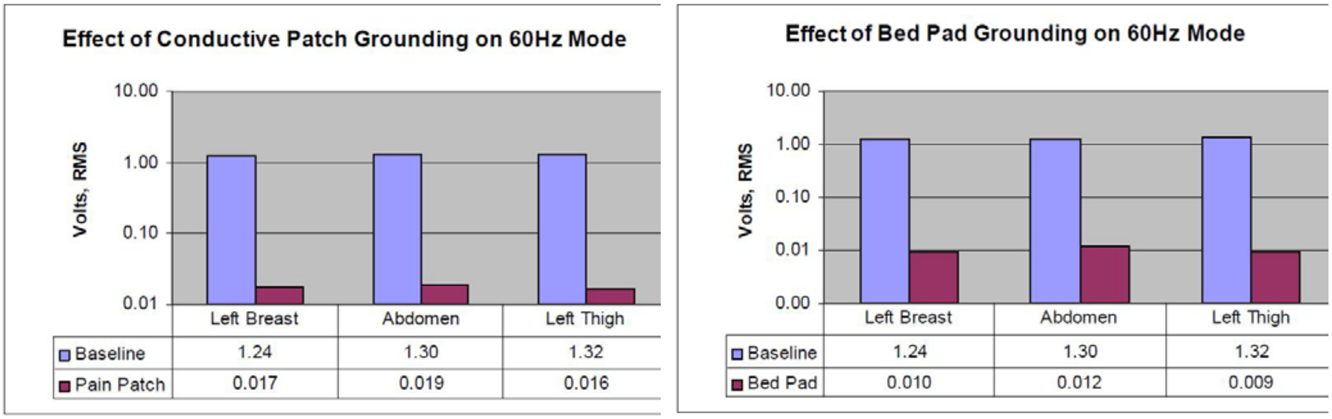


Figure 2: Effect of conductive patch (left) and bed pad (right) grounding on 60 Hz frequency mode.

Mr. Applewhite's results can be easily replicated using a commercially available and inexpensive voltmeter or multimeter (Figure 3). We recommend multimeters because of their versatility. They measure voltage as well as other parameters such as current and resistance.

Figure 3: Multimeter.

The meter can be used to determine how much voltage (a measure of energy per unit electric charge) is being induced onto a person's body, and how much the voltage is reduced by grounding.

The positive terminal is usually identified by a red wire connected to the "Volts" port of the multimeter. The negative terminal (a black wire) connects to the "Com" port, and then to the ground − preferably a rod in the Earth or a good ground from the electrical system of a building (grounded wall outlet). The meter must be grounded in order to conduct this measurement; and both the meter and the Earthing product must be connected to the same ground reference.

Figure 4 shows two ways of connecting to the same ground source. In the left picture, an Earthing splitter is inserted into the grounding hole of a power outlet; the cord going to the meter is inserted on one side of the splitter, while the cord going to the Earthing product is inserted on the other side of the splitter. The right picture shows that one can use a power strip to produce the same result. With either method, an alligator cord is used to connect the meter lead to the Earthing cord, as seen in the right picture.

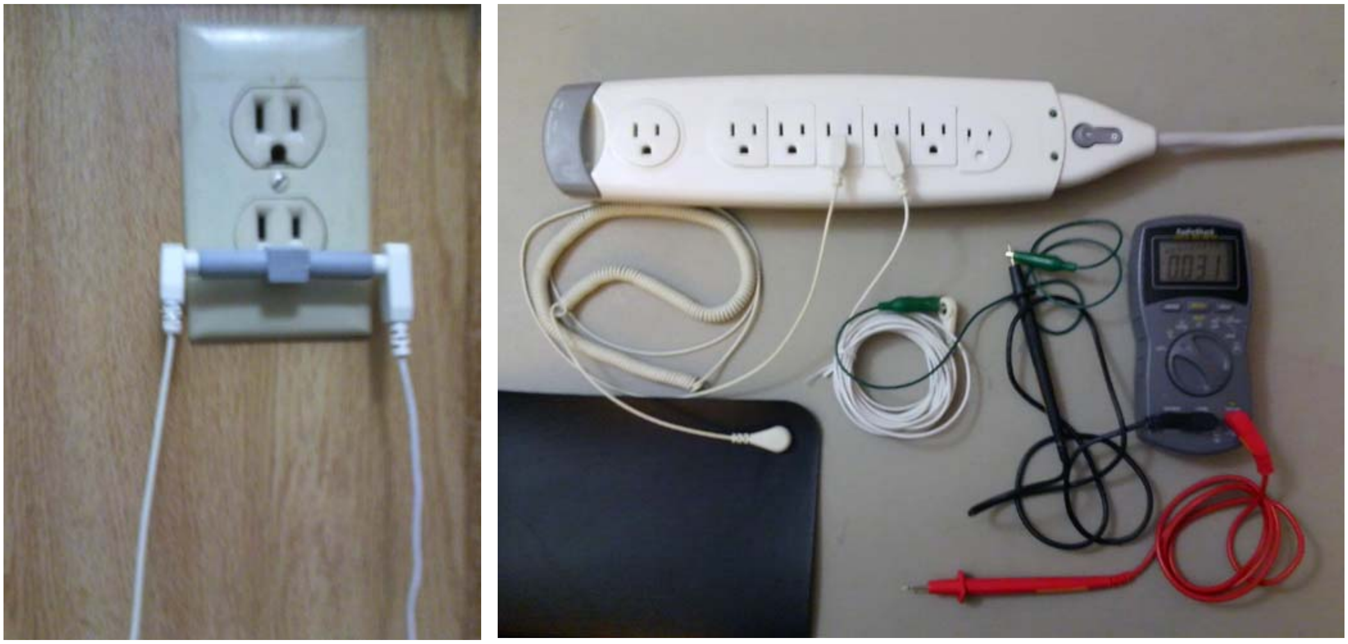


Figure 4: Left: Using a splitter; Right using a power strip.

 To check if you have a good building ground you can use a circuit/outlet checker, as shown in Figure 5 below.

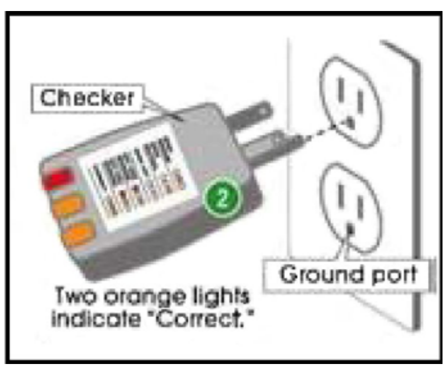


Figure 5: Circuit/outlet checker.

In Figure 3, the person is holding the metal tip of the red wire between the index and thumb, which is how to measure body voltage. The dial has been set to "Volts AC" or "VAC."

The voltage measurements illustrated in Figure 6 were made using a multimeter. The person's right thumb and index fingers hold the tip of the positive terminal, just as in Figure 3. The negative terminal has been connected to the house ground. In the left image, the meter shows a body voltage of 8.35 volts AC induced on a person who is in contact with a grounding mat disconnected from the ground wire (the white wire next to the person's hand). The number refers to the amount of 60 Hz AC voltage induced on the mat and body by ambient electromagnetic fields (EMFs) in the room. When the grounding wire is attached to the grounding mat connecting it to the Earth, the body voltage of the person in contact with the mat instantly drops to 0.09 volts (right image). This is a 93-fold decrease from the ungrounded condition, a result similar to what was observed by Applewhite.

Figure 6: Left: The white grounding wire to the left of the hand is connected to a rod in the ground but it is not touching the grounding mat. The mat and the person touching it are ungrounded. The meter shows a voltage of 8.35 volts induced on the body. Right: The wire is now connected to the grounding mat. The mat is grounded, and when the person touches the mat, she too becomes grounded. The body voltage has dropped to 0.09 volts (90 mV), the level of the EMF background noise.

The grounded result will vary according to the EMF noise in the immediate environment. The ambient voltage in this example of 8.35 volts was quite "noisy," that is, a relatively high level of EMFs in the room. Close by was a lamp with two compact fluorescent light bulbs that emitted a good deal of EMFs. A level of this nature can be encountered in bedrooms with many appliances present, such as lamps, clocks, and radios. Additionally, if you take a measurement while sitting on a bed that may be close to a wall, there will be a contribution from the electric wires in the wall, creating more EMFs in the sleeping area. Thus, you can get a wide variety of readings, ungrounded and grounded, depending on your location of measurement.

Here's another example:

Measurements were taken of body voltage on a person sitting on a bed with her back against the headboard next to a wall. See what happens as we systematically turn off and then disconnect appliances in the room, one by one. The appliances were: 2 small bed lamps, 2 tall floor lamps, 1 radio, and 1 alarm clock. All appliances were plugged in and turned on at first, then turned off and finally disconnected with the exception of the alarm clock and the radio which were turned on and then disconnected.

- 3.639 volts with all appliances turned on
- 3.329 volts with radio disconnected

- 3.267 volts with 2 small bed lamps turned off
- 2.733 volts with 2 small bed lamps disconnected
- 2.588 volts with 2 standing lamps turned off
- 2.462 volts with 2 standing lamps disconnected
- 1.434 volts with the alarm clock disconnected
- 0.041 volts grounded using a grounding mat with all appliances disconnected

Note that even after all appliances were disconnected the body voltage was still 1.434 volts. This body voltage was produced by the wires in the wall against which the bed was placed. Grounding the person decreased the body voltage − with all appliances disconnected − from 1.434 volts to 0.041 volts, a factor of 35, and by a factor of 89 when all appliances were turned on (from 3.639 volts to 0.041 volts). Note also that disconnecting an appliance is more effective at reducing body voltage than turning it off.

Some German researchers have suggested that the method for measuring body voltage presented above does not accurately assess exposure to 50/60 cycle AC electric fields. We disagree. In their experiments they used sophisticated "potential-free, 3D E-field" probes, also referred to as "cube sensors," to measure the fields above and below a person using an Earthing pad. They found an increase in the field strength in the space above the person, which they interpreted to mean that Earthing is "contraindicated."[2] However, there was a major problem with their experiment: they placed the Earthing pad beneath the mattress, so there was no direct conductive contact between the Earthing system and the skin of the subject. Thus, the experiment and conclusions were not related to grounding the body. The person on the bed was not, in fact, grounded!

Using the Multimeter to Measure Sources of EMFs that Produce Body Voltage

There are two methods to find and measure the magnitude of the EMF sources – such as appliances and wiring − that induce body voltage. As the name imply, EMFs are composed of both electric and magnetic fields, but it is the electric field component that induces body voltage. Thus, measuring body voltage does in fact measure the effect of the AC electric field component of the EMF on the body.

The first method is by measuring the body voltage itself. This is depicted in Figure 7, using a multimeter similar to the one used in Figures 3 and 6.

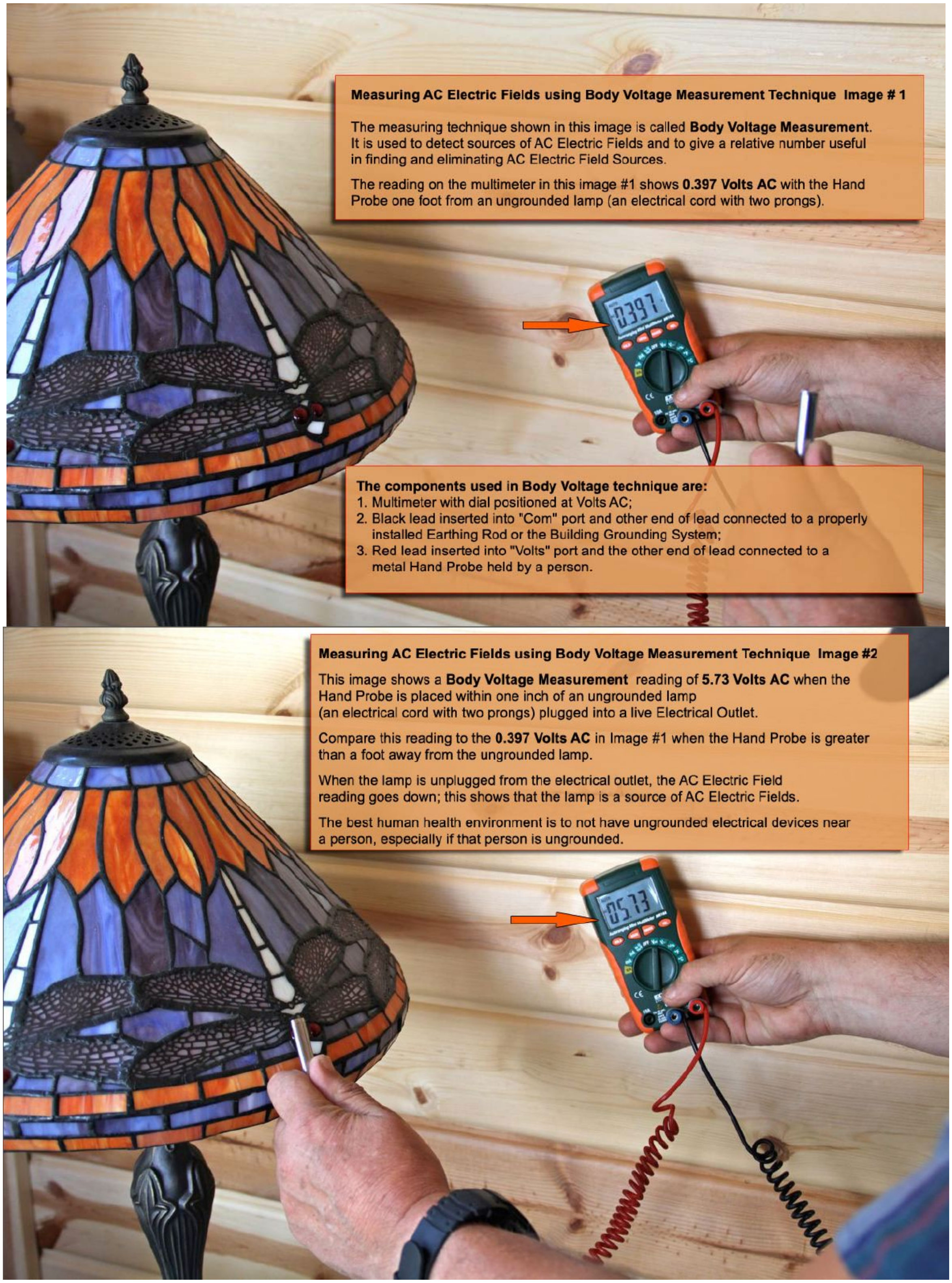


Figure 7: Method of measuring EMFs emitted by appliances through AC electric fields producing body voltage. Image #1: the hand probe is one foot away from an ungrounded lamp and the body voltage is rather low at 0.397 volts. Image #2: the hand probe is within one inch from the lamp and the body voltage now reads at 5.73 volts, an increase by a factor of 14.4.

First, make sure to set the dial at “Volts AC.”

Insert the black lead into the “Com” port of the multimeter and connect the other end to a dedicated ground rod outside or to the building grounding system after checking it has a good ground with the circuit/outlet checker.

Insert one end of the red wire into the “volts” port of the multimeter. Attach a metal probe to the other end, as shown in Figure 7, or hold the metallic lead in your hand, as shown in Figures 3 and 6.

Figure 7 illustrates that if the appliance (here a lamp) is the source of the EMFs, the body voltage will increase when the metal probe is moved closer to the appliance. If the probe is maintained close and the body voltage goes to zero when the lamp is unplugged, this is further indication that the lamp was really the source of the EMFs.

Using a Non-Contact AC Voltage Sensor

The second method employs a non-contact AC voltage sensor. Some examples are shown in Figure 8. They are inexpensive, easy-to-use, hand-held devices available at hardware stores or online.

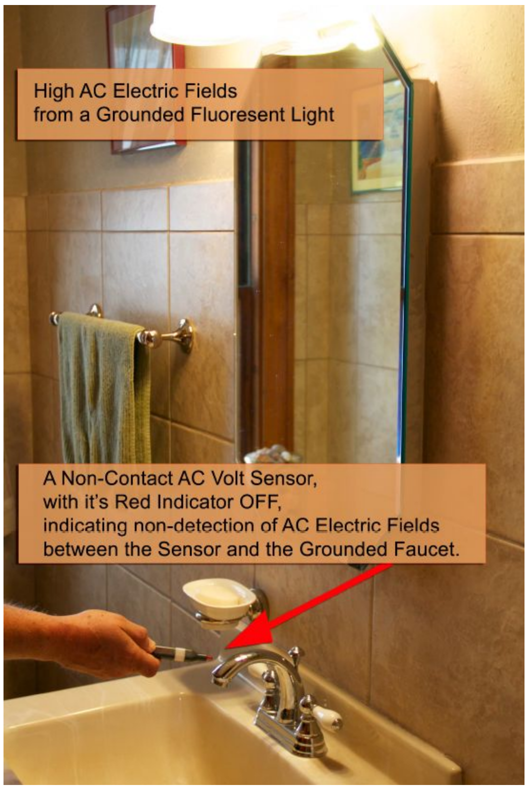
Figure 8: Five commercially available non-contact AC voltage sensors.

There are different types of non-contact AC voltage sensors. Some of them utilize light, others sound, and still others a combination of light and sound when close to a source of EMFs. For instance, a sensor will light up when close to a lamp, and then go out when the lamp is unplugged, proof that the lamp is the EMF source, as shown in Figure 9 below.

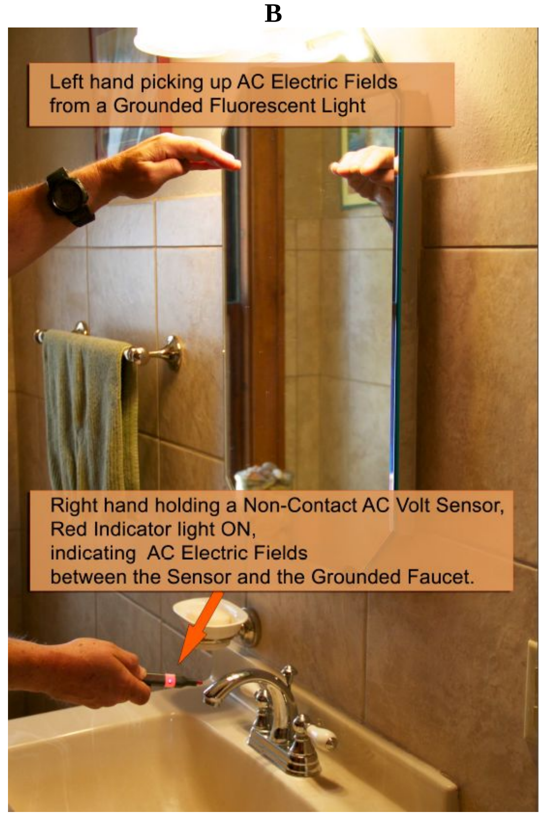
Figure 9: Method of measuring EMFs emitted by appliances using a non-contact voltage sensor. Image #3: the sensor is one foot away from an ungrounded lamp and the indicator light is off, indicating a low level of EMFs. Image #4: the sensor is close to the lamp and the indicator light is on, indicating a high level of EMFs.

Although simple to use, non-contact AC voltage sensors can give wrong indications if not used properly, as shown in Figure 10 below. Here, the faucet is grounded and the source of EMFs is the fluorescent light above the mirror. In Figure 10A, the sensor is held close to the faucet with the right hand, and the fluorescent light is turned on. The sensor red light indicator remains off, correctly indicating no EMFs close to the faucet. In Figure 10B, the situation is the same except that the person placed his left hand close to the fluorescent light. The sensor indicator now lights up giving the incorrect impression that the faucet is emitting EMFs. What is going on here? By placing his left hand closer to the EMFs emitted by the light, voltage has now been induced on the person's body – the whole body, including the hand holding the sensor. This hand now emits EMFs that are detected by the sensor. That's why the red light goes on! The closer to the source of the voltage (the lamp), the higher the electric field. The farther, the weaker the field.

A



B



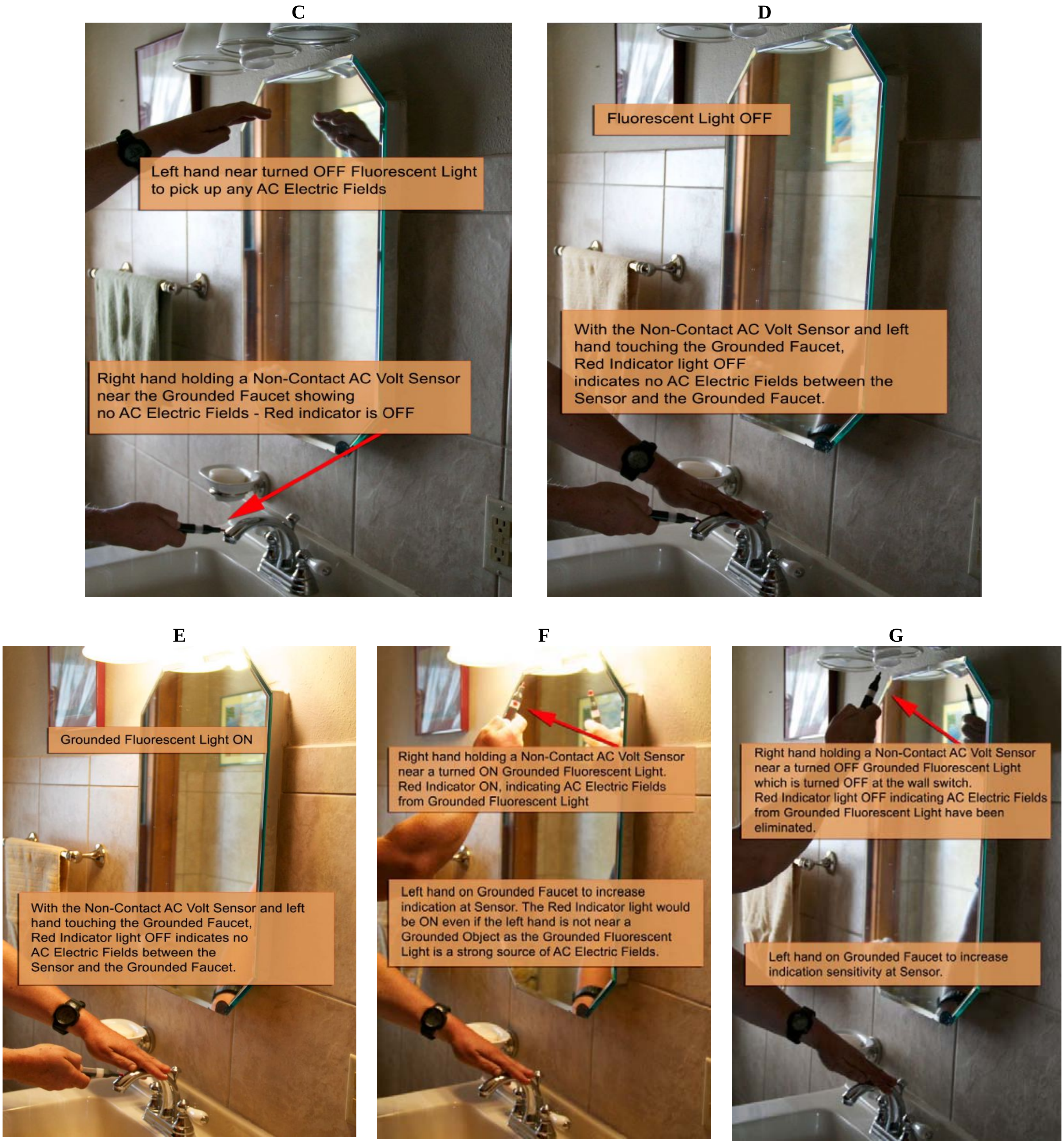


Figure 10: Demonstration of what can go wrong while measuring EMFs emitted by appliances using a non-contact AC voltage sensor. A: the fluorescent light is on and the non-contact AC voltage sensor is held close to the faucet, the red indicator is off. B: the non-contact AC voltage sensor is held close to the faucet with the right hand while the left hand is close to a lit up fluorescent light, the red indicator is on. C: the non-contact AC voltage sensor is held close to the faucet with the right hand while the left hand is close to a fluorescent light that is turned off, the red indicator is off. D: the non-contact AC voltage sensor is held close to the faucet with the right hand and the left hand touches the faucet with the

fluorescent light turned off, the red indicator is off. E: the non-contact AC voltage sensor is held close to the faucet with the right hand and the left hand touches the faucet while the fluorescent light turned on, the red indicator is off. F: the non-contact AC voltage sensor is held close to the fluorescent light that is turned on with the right hand and the left hand touches the faucet, the red indicator is on. G: the non-contact AC voltage sensor is held with the right hand close to the fluorescent light that is turned off and the left hand touches the faucet, the red indicator is off.

How to prevent such false readings with a non-contact AC voltage sensor? The answer is shown in Figure 10E. Here, the person's left hand touches the grounded faucet. The sensor's red indicator is off, correctly indicating that there are no EMFs emitted by the faucet. In Figure 10F, the person touches the grounded faucet with the left hand while holding the sensor close to the turned-on fluorescent light with the right hand, making the red indicator light up, correctly showing EMFs being emitted by the fluorescent light. Figure 10G shows that when the fluorescent light is turned off and the person is in contact with the grounded faucet, the sensor's red indicator stays off, correctly showing no EMFs being emitted by the fluorescent light.

In summary to avoid having false positive readings with a non-contact AC voltage sensor, the person holding it needs to be grounded (be sure that the ground is a good one).

REFERENCES

[1] Applewhite, R., 2005. Effectiveness of a Conductive Patch and a Conductive Bed Pad in reducing induced human body voltage via the application of earth ground. European Biology and Bioelectromagnetics 11/03/2005 issue, pp. 23–40.

[2] Virnich, M.H. and Schauer, M., 2005. Caution, grounding pads and sheets: Being grounded is not equal to zero-field exposure. De–der Elektro- und Gebäudetechniker, November issue. http://buildingbiology.ca/wd/wp-content/uploads/2012/08/FINAL_ACHTUNG_ABSCHIRMDECKE_WEB.pdf