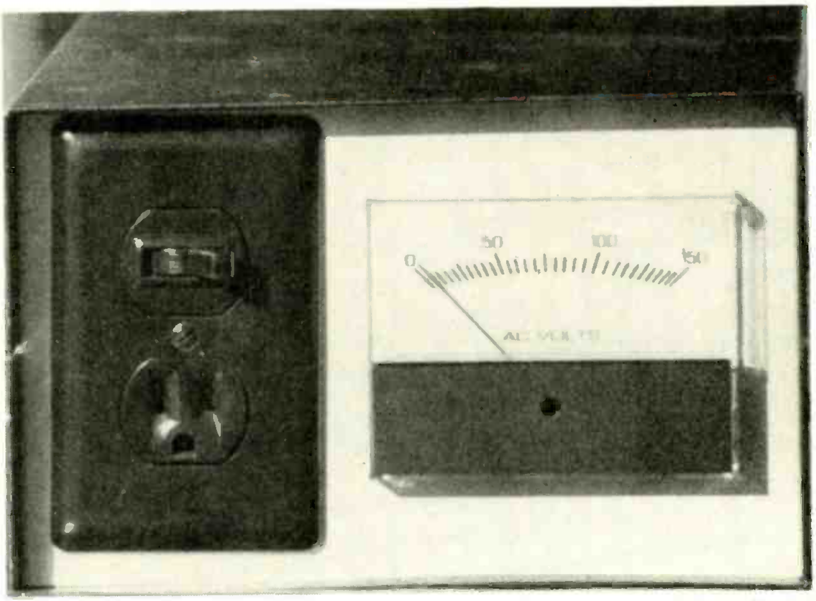
Isolate Yourself and Stay Alive!



Our hobby is fun, but it is easy to make a mistake that could do you harm. Our Isolator prevents problems so you can avoid cures.

BY JOSEPH J. CARR

Few people see electronics as a potentially dangerous hobby on a par with, say, motorcycle racing or watching a British soccer match; but there is danger aplenty for the the unaware or careless hobbyist. The 110-volt alternating current from an AC-power socket can wrench your life away from you wihtout much ado.

And don't believe a lot of "old wives tales" about it being current that kills, not the voltage, whatever *that* is intended to mean. A 117-VAC line is dam dangerous and will kill you. Unfortunately even physicians believe such misinformation (sigh). For almost eight years I worked in the bioelectronics laboratory of a major east-coast medical center. One day I overheard an intern stating with annoying authority: "They told us in medical school that it's not the voltage that kills, but the current; so don't worry about the 117 volts from the wall socket—it's safe."

I looked across the table at him and asked in a semi-sarcastic tone: "Have you ever heard of Ohm's law, Doctor?"

What the young doctor was unknowingly referring to is the fact that the presence of high current density in a certain region of the heart is what causes death by electrocution. The mechanism of death is *ventricular fibrillation* (irregular and uncoordinated heart action), which leads to death in minutes if no one initiates cardiopulmonary resuscitation (commonly called CPR) and gets the victim to the hospital immediately. Since immediate CPR treatment is the only support mechanism that will get the victim to the emergency room alive, it is wise for all shops to have a few people trained in CPR. Also, families in which a member works with electronics would do well to have another member trained in CPR.

Source of the Danger. Figure 1 shows a simplified schematic of the standard residential-power system used in the United States. The power company distributes electrical power in the form of high-voltage alternating current (denoted HVAC). That form of current can be more efficiently transmitted than low-voltage current because the ohmic losses are less. When the power line gets to a point close to your home it is connected to a step-down transformer (called a "pole pig") with a center-tapped secondary that produces about 240 VAC across the two extreme ends, and 117 VAC between the grounded center-tap and either extreme end. That is the reason why the power company brings three lines into your home: neutral (which is grounded at some point), HOT1, and HOT2.

Those lines are distributed to the branch circuits in your home through an electrical box (or fuse box). Each 117-VAC line consists of at least two wires: a hot line and the neutral. Most modern outlets also have a ground line that is connected to the electrical box at the service entrance.

So, where's the trouble? If you are barefoot, or are wearing conductive shoes (such exist!), or have canvas, rubber or leather soles that are soaking wet, then you are effectively grounded. Accidental contact with the 117-VAC hot line will allow current to pass through your body, setting off ventricular fibrillation—leading to death.

There are a number of dangerous scenarios that can lead to injury for an electronics hobbyist: frayed power cords on power supplies or tools; troubleshooting live equipment without paying careful attention to where the AC snake is coiled; plugging in a project that is not ready to receive power safely; and the list goes on.

The Solution. The best solution to the problem is to "lift" the AC power line off ground through a floating-AC power system. Figure 2 shows a transformer-

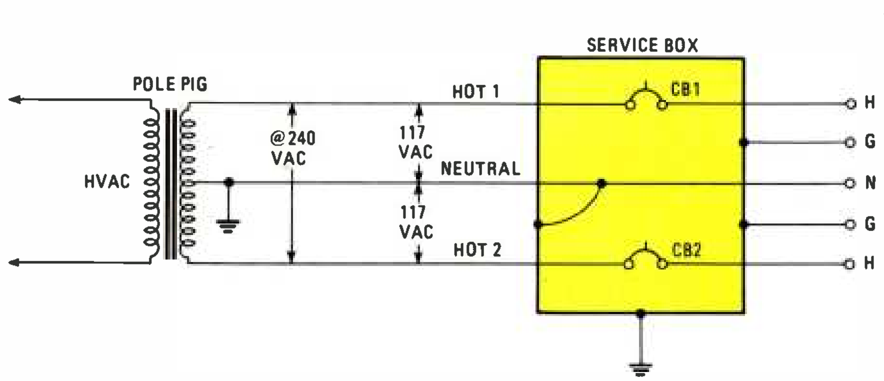


Fig. 1. Unlike what you may have imagined, two hot lines enter your house at the same time; each of them carries 117 volts potential to ground (also used as neutral).

isolated AC power system. The transformer has a 1:1 turns ratio so 117 VAC can be "converted" to floating 117 VAC. The important thing to note is that the primary circuit is ground referenced because the AC power line is grounded through the neutral, but the secondary is completely floating—neither line is connected to ground.

The isolation-transformer idea is an old one, and one you should take advantage of if you work on live circuits or in building DC power supplies. In a hospital, it is common practice to use an isolated power supply in each operating room for patient safety. In fact, if you are unfortunate enough to have surgery, take note of the stainless-steel alarm panel on which the clock is mounted. Behind that panel is a 5-, 10-, or 20-KVA isolation transformer and various monitoring devices to keep the system safe.

Television- and audio-service technicians also use isolation transformers. One of the photos shows a typical service-person's isolation transformer. Such devices allow the service technician to adjust the voltage level to the specified value (e.g. 117 VAC) even though the actual line voltage is anything between 105 and 125 VAC.

Alternatively, the technician might want to set the voltage either lower or higher to check some particular aspect of the device under test.

Another form of isolation transformer is for use with computers, digital electronics, and other sensitive instruments (see photo). It not only provides necessary isolation, but also noise suppression. The author has seen those transformers solve a lot of odd intermittent problems in computer installations. Power-line transients can disrupt digital circuits (of course including computers), and the transformer suppresses those transients.

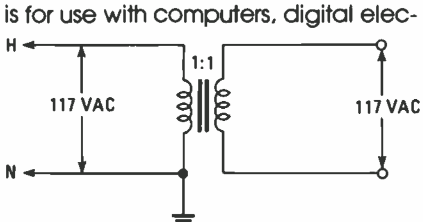


Fig. 2. The 117 volts that is grounded on the primary (power) side of the transformer, is lifted in the secondary.

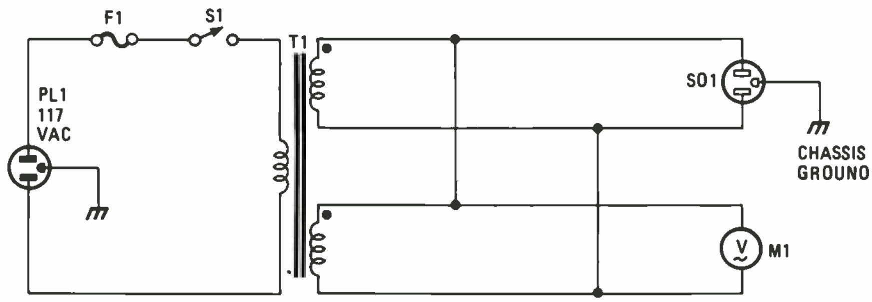


Fig. 3. The dots above the secondary coils for the Isolator indicate their phasing. Be sure they are in phase before completing the wiring of the unit.

PARTS LIST FOR THE ISOLATOR

F1—6-amp fuse (based on transformer value; see text.)
M1—150-VAC meter
PL1—Three contact AC-line computer plug
S1—AC-power switch, wall-mount type or equivalent.
SO1—AC-outlet type socket
T1—115-VAC, isolation transformer

Computer power cord, cabinet, face plate (if needed; see text), fuse holder, grounding lugs, locknuts, screws, solder, wire, etc.

A 115-volt, 0.2-amp per secondary transformer, Type PPC-29, (stock no. 44F2392) is available from Newark Electronics; Tel. 312/989-7800 for the branch nearest you.

Making Your Own Isolation Unit. Isolation transformers can be bought from any number of sources, including many major electronic-parts suppliers. They can also be bought from electronics-surplus outlets, or local electronics parts stores. I bought an industrial-surplus transformer at a local shop and built the bench isolator shown in the photos.

Figure 3 shows the circuit for the isolator box that I built. The transformer has three 117-VAC windings. The transformer mentioned in the Parts List is rated at 115 volts, so keep that in mind if you build your Isolator with that unit. The primary winding is connected to an AC power switch, S1, and a fuse, F1. It receives power from the AC line through a standard computer cord. The size of the fuse depends on the size of the transformer. The transformer used in the prototype was a 650 volt-ampere unit, so by 650-VA/117-V we know that it will produce a little more than 5 amperes. That is more than the unit specified in the Parts List will produce, so select a more powerful (read that: more expensive) unit if you require it. (The supplier mentioned in the Parts List offers a wide variety of appropiate units.) I selected a 6-ampere slow-blow fuse accordingly.

Note from the photo that the AC outlet and the power switch are part of the same assembly, mounted behind an outlet cover plate. Both the cover plate and the switch/outlet were purchased at a local hardware store. The output meter is a 0–150-VAC meter bought at a local electronics supply house for about $16. The cabinet is a standard hobbyist-grade metal cabinet. The fuse holder and power socket are mounted on the rear panel of the unit.

It is important that you connect the ground lead from the AC input socket on the rear panel, and the ground lead from the AC outlet on the front panel, to the chassis. The paint should be scraped off the chassis if necessary,

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and a locknut and grounding lug used to secure the ground leads from the sockets to the chassis. Use either a pop rivet or an aircraft grade or locking nut and a 6-32 machine screw to hold the grounding lug.

Alternative Wiring. The secondary windings of the transformer can be wired in three useful ways. You can connect them in parallel with each other to provide a single high-current 117-VAC output. If you connect them in parallel and find the output voltage is zero, then you have connected them out of phase and the two windings are cancelling each other. If that happens, reverse the wires of one (not both) of the windings, and the expected output voltage will be found.

Alternatively, the secondaries can be left floating independently to form two separate 117-VAC outlets, or an outlet and a meter readout like the author's, each of which have half the available power. Finally, we can connect the secondary windings in series (see Fig. 4) to produce a single 240-VAC outlet.

Interestingly enough, it is possible to connect the transformer backwards so that the series-connected "secondary" becomes the primary, and thus drops 240 VAC to 117 VAC. That can be done for use overseas where 230 VAC is common, or in specific applications in the USA where 240 VAC is ordinarily used. That does require a more powerful transformer than the one listed, so pay attention to the specifications of the one you select.

An isolation transformer on your workbench can save your life. It's a no-nonsense solution to a potentially dangerous situation. You and your family will not regret the small investment that is required. ■

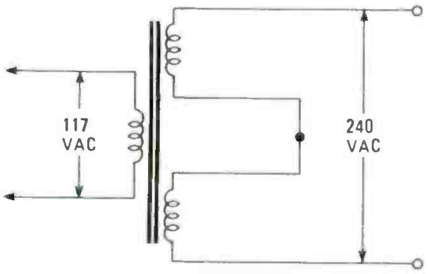
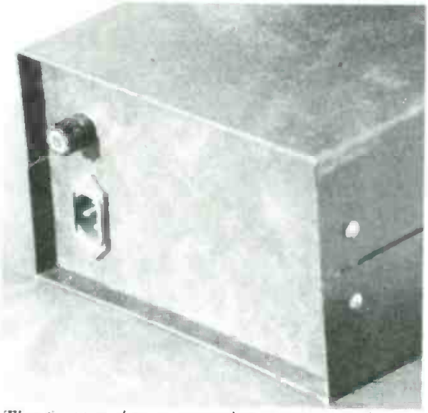
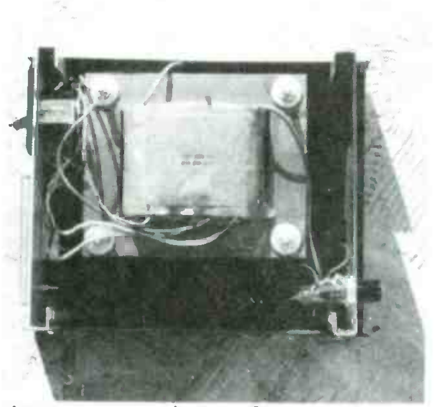


Fig. 4. By modifying the transformer hook up, you can obtain a useful voltage adapter for travel.



The fuse and power socket are located on the back of the author's unit to avoid front-panel clutter.



As you can see, the transformer is the project. Since the cabinet huddles the other parts around it, insulate well.

This professional isolator allows a technician to select the output voltage for the device under test.

Isolators are great devices to protect computers from power-line problems.