Keywords: CMOS, ESD, power supply, phantom load, battery, electricity, surge protection, EMI, powerline, vampire power

APPLICATION NOTE 5345

Want Some Free Electricity, One Month a Year?

By: Bill Laumeister, Strategic Applications Engineer
Oct 01, 2012

Abstract: The "vampire" drain on electricity by household gadgets is only one indicator of the lack of policies to conserve energy and protect people and businesses from a major energy disaster. Most consumers are not aware of this, and many don't understand that they could save up to 10% on their annual electric bill with just a little effort.

A similar version of this article appeared on *Electronic Design*, August 20, 2012.

Introduction

Not that many years ago, electronic devices had a "hard" power switch that meant what it said—when turned to OFF, the device was truly *off*. It drew no current.

The invention of the radio and then the TV remote control changed that. The first remote controls were not very popular as they were hardwired and the wire posed a trip hazard.[1] The Philco® "Mystery Control" in 1939 was a wireless radio transmitter to control a home radio receiver.[2] The Zenith Radio Corporation tried wired-TV remote controls with wires in the early 1950s. However, remote controls really took off in 1955 and 1956 when Zenith introduced the Flashmatic followed by the Space Command remote controls.[3] The Zenith® Flashmatic was a glorified flashlight with photocells in the TV set. Space Command used mechanical buttons that struck aluminum rods that produced ultrasonic tones. The remote receiver inside the TV has to be powered all the time, or there would be no way to turn on the TV from the comfort of one's seat. The receiver had a separate power switch, so its power-hungry tube circuitry wouldn't run up the electric bill while the family was on vacation. (This switch worked, of course, assuming the head of family remembered to shut it off.)

That "indirect" power control has since widened to become today's "soft" power switching used by just about every electronic device, whether battery or line powered. The device sits poised in standby mode, pulling some current, until the power switch commands the control circuitry to get the unit up and running.

Soft power control was developed out of necessity. In tutorial 5274, "It's Hot! Why Are My CMOS Logic Circuits Burning Up?," we discussed the importance of applying power in a sequence that would not cause unexpected behavior, system lockup, or even damage. Soft control not only permits an orderly powering-up and powering-down, but it also lets the unit's microprocessor (what electronic device *doesn't* have one?) perform system checks and report problems. When you gripe about how long your TV takes to run through its POST before you can watch football from dawn to dusk, remember that it is the price you pay for a sophisticated HD display.

Electrical Vampires of Suburbia

Standby current drain is commonly referred to as *phantom loads, leaking electricity,*[4] or—most frightening of all—vampire power. Most consumers are not aware of how many electronic devices drain power, even when they do not seem to be "on." These include:

- Remote-control systems in audio/video equipment (**Figure 1**)
- Clocks and timers (particularly in microwave ovens, ranges, and iPod® docks)
- Computers and computer peripherals
- Battery chargers
- All manner of gadgets and small appliances, especially those with external power supplies

External supplies—derisively dubbed "wall warts"—are notorious power drains. To reduce size and cost, most use undersized transformers with low primary inductance, thus drawing excessive current. They remain warm to the touch even when the device that they power is shut down. Granted, the "excess" current is only 10mA or 20mA. But when a household has a dozen of these plugged in 24/7, there is a measurable increase in the electric bill.

"Count"ing the Cost

Vampire power is estimated to "eat up" 5% to 10% of consumer electricity in developed countries.[5] Saving this power by unplugging devices or shutting off power strips could give consumers "free" electricity for one month a year. It might also reduce the growth rate of new power plants.

Vampire power's economic drain has been recognized for almost two decades. Since the 1990s, both government and industry have set goals to reduce vampire power.[6] In 2010 the goal was to cut standby power to less than one watt. Regulations for 2013 further reduce the draw to less than half a watt. (If half a watt doesn't seem like a lot of power, do the math: 10 devices per home x 100,000 homes x 0.5 watts per device.)

Energy waste can also be reduced by eliminating unneeded features and functions. Does a microwave oven's clock *have* to be on when you are not cooking or timing? Some estimates suggest that this always-lit clock represents half the cost of operating the oven.[4]

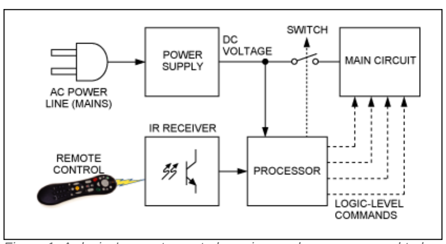

Figure 1. A device's remote-control receiver and processor need to be powered to switch the main circuit on. Other than unplugging the set, most current (sorry!) devices don't have a way to shut off the R/C receiver.

Vulnerable AC Power

Figure 2 shows a well-equipped utility pole. At the top is three-phase high-voltage wiring (typically 2kV to 30kV). Transformers (the gray cylinders) step down the high voltage to 120V/240V for household and nonindustrial business use. Lower on the pole are thin coax lines for cable TV, and a heavier cable for telephone.

A wind storm, heavy snowfall, or out-of-control vehicle can break the high-voltage lines. When these fall on other lines, hundreds (or thousands) of volts surge through your appliances, telephone, or cable connection, before the breakers or fuses open. Any device connected to the powerline—whether on, off, or in standby—will almost certainly be damaged.

The power grid itself can be the source of problems. Damaging spikes and transients can occur during load balancing, or when large inductive loads (motors and refrigeration equipment, in particular) are turned on and off.

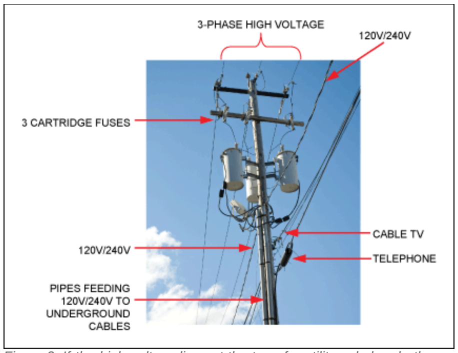

Figure 2. If the high-voltage lines at the top of a utility pole break, they can land on the lower-voltage power and communication lines.

Telephone Line Protection

Telephone companies have long histories of protecting against high-voltage wires falling down on their lines. For example, Janski and Faber's 1916 book **Principles of the Telephone**[7] discusses falling trolley wires, lightning arrestors, and other types of high-voltage protection. Metallic spark gaps work well, but are costly because they melt and require manual replacement. A better alternative uses carbon blocks (**Figure 3**), which can tolerate many strikes before needing replacement.

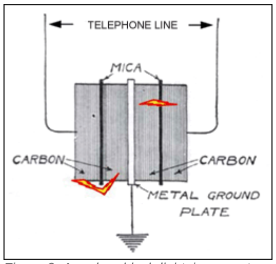

Figure 3. A carbon block lightning arrestor provides protection, without requiring replacement after each strike.

Typically, two carbon blocks are separated with a mica sheet five- to ten-thousandths of an inch thick (Figure 3). The example in **Figure 4** shows how arrestors protect a phone line from direct contact with 600V from a trolley powerline.

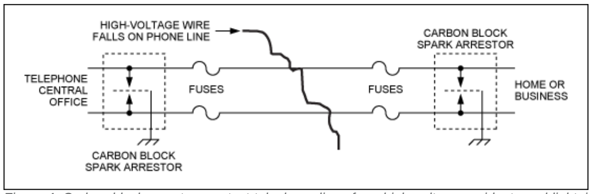

Figure 4. Carbon block arrestors protect telephone lines from high-voltage accidents and lightning.

Both sets of fuses open when current arcs through the air around the mica spacer. The carbon block can also have an embedded low-melting-point metal slug. If arcing doesn't blow the fuse, the metal melts and shorts the arc gap, drawing enough current to melt the fuse. (**Figure 5**)

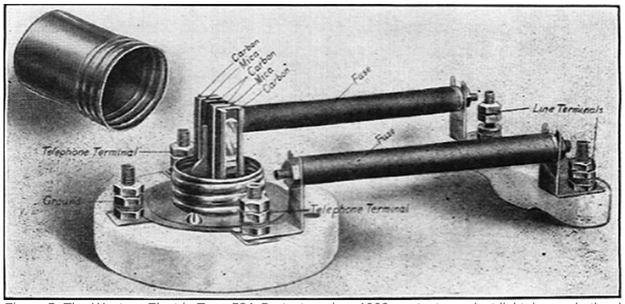

Figure 5. The Western Electric Type 58A Protector, circa 1900, protects against lightning and other high voltages.

For lightning, the advice in the instruction manual remains sound: "Do not use your wired phone during electrical storms." (Ditto for not taking showers.)

Surge Protection Devices—Safeguard or Hazard?

Surge protection devices (SPD) commonly called surge suppressors protect equipment primarily by clamping voltages exceeding normal line levels.[8] The "let through voltage" is dependent on the wire length and powerline impedance and, thus, can be misleading to consumers. An IEEE® presentation graphically simplifies the concept of SPD specifications. Voltage spikes drive the clamping devices (usually metal-oxide varistors—MOVs) into conduction, shorting out the spike. Each "event" slightly damages the MOV, and it eventually fails to protect.

Most surge suppressors still operate as power strips, even when the suppression mechanism no longer works. The next big surge could damage equipment or so overheat a MOV that a fire starts.[9] MOVs should, therefore, be paired with a thermal fuse or thermal cutoff (TCO) device to prevent this.[10] The suppressor should also have an indicator light to monitor the condition of the TCO and MOV, but few do.

When purchasing a surge suppressor, look for the following features:

1. A circuit breaker, to prevent overheating and fire if the power strip is overloaded.
2. A light indicating whether the protection components are functioning.
3. Approval by an industry, insurance, or government testing body (such as Underwriters Laboratories—UL). UL 1449 sets the minimum standards for SPDs. The reference lists other parallel standards in a 30-page book.[11]

The suppressor's joule rating (how much energy it can dissipate in a single event) isn't considered a meaningful indicator of the suppressor's effectiveness or longevity.[12] It's the overall design that matters.

Watch out for power strips with *no* surge suppression! They're little more than elaborated extension cords.

The Ultimate Inspector Saves Lives and Money

In addition to selecting a "quality product," there are other things we can do to be sure a surge suppressor is delivering the protection it's supposed to. Any part of the surge suppressor could fail, even the circuit breaker. The most important thing we can do is to **regularly inspect** surge suppressors, wiring, plugs, and appliances. The stakes are high; the lives we save are our own and our families. In addition, we should have working smoke alarms throughout our homes.

For surge suppressors:

1. If the unit has a PROTECTION light, is it on? If not, one or more of the suppression components has likely failed. Replace it.
2. Is the suppressor unduly warm? If any area is hot to the touch, the suppressor should be immediately removed from service.
3. Ditto, if any part of its surface is discolored.

Remember that the money that we can save by turning off the switch on the surge suppressor is our money. The thought of having free electricity for one month a year is quite an incentive to flip a switch.

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