Heat

Very early on in the development of knowledge, ancient scientist began to realize that there was something more to matter than just the chemical elements.

About 2500-years ago, the Sicilian Empedocles (em-ped-uh-kleez) decided that everything was made up of four elements — water, earth, air and fire — the mixture or separation of which were effected by two powers — love and strife … meaning forces of attraction and repulsion.

About 23 centuries later, the German scientist Friedrich Mohr wrote something very close to today's understanding of the *Law of Energy,* which says that energy can neither be created, nor destroyed, but is merely transformed from one state to another.

As an electronics genius, why would you care anything about this?

First, electricity and electronics typically involves the conversion of energy from one form to another …

- mechanical
- chemical
- electrical
- thermal
- light
- heat

… in order to provide some useful function or service …

Second, these processes are always less than 100% efficient, meaning that only a fraction of the energy employed goes toward providing the intended function or service.

…As we've already seen, the light emitted from an incandescent light bulb, on average, accounts for only about 5% of the power applied to it. The remainder of the input power is usually being wasted … “wasted” but not “lost”.

In this particular case, as in most cases in electronics, the part of the applied energy that represents inefficiency winds up as heat — an unwanted and potentially troublesome byproduct that absolutely must be dealt with.

In the extreme, heat can be destructive. Most electronic components have no inherent protection against overheating, and will be perfectly happy sitting there with smoke rolling out as they burn themselves up.

Back in my old Air Force days, when methodical troubleshooting wasn’t pointing to the problem, we used to say, ‘Well, let’s give ‘er the old “smoke test!” … meaning to short out the fuses, then turn on the power and watch where the smoke came from.

But beyond the rare instances of catastrophic failures, practical electronic components are also less than perfect, and are almost always affected by temperature. Their proper functioning, and the accuracy of the circuit they're used in, depends upon keeping them within a specified temperature range.

That is accomplished through careful electrical and mechanical design, the use of *heat sinks*, and sometimes forced air ventilation.

If you've ever taken the cover off your computer case, you've seen what that looks like in action. The main processor, and perhaps the video processor, are covered by fan-equipped heat sinks, the power supply has a blower to exhaust heat from within the case, and the case itself might have an intake fan. There's always a demand for faster and faster processors, and increasing speed necessarily brings with it increased thermal management problems.

A “heat sink” is nothing more than a chunk of metal, usually aluminum, which is used to absorb heat from some high-dissipation component. It usually has fins which help dissipate the heat into the surrounding air, and often has provisions for mounting a fan, which greatly enhances its dissipation capabilities. Heat sinks in ultra-fast gaming computers are even sometimes water-cooled!

Generally speaking, heat can always be considered anathema to electronics, and should always be a concern. Anything that is getting hot suggests a malfunction of some sort, and should be an item for special attention.

Story time!

Back when practical linear ICs began to become available, they came in nice, military-grade, TO-5 packages at first … ceramic sealed “tin cans”, with gold-plated leads. As I’ll tell you later, I was a keen early adopter because they solved a serious personal problem …

transistor theory was a baffling enigma to me! Try as I might, I just didn’t get it.

My boss didn’t know that, of course. I was his “boy genius”. He was really proud to show me off to visiting customers, pointing out our use of that cutting-edge technology in the new products that I was designing.

Unfortunately, at that point linear technology was still in its infancy, and the devices were notoriously failure-prone right out of the box! Nothing we made ever made it through testing without a bunch of rework.

My young cohort, Jim Diekema, was our lead test technician. His first step in testing a newly assembled instrument … a somewhat “low tech” procedure … was to lick his index finger, apply the power, and then quickly go down the rows of ICs, touching the top of each can and tagging the hot ones with a black marker. His index finger frequently got fried!

A cheap pair of night-vision goggles, had such a thing been available back then, would have been a real handy troubleshooting tool.

For future reference … whenever you're troubleshooting a troubled piece of electronic gear, a good first step is to look for something that's hot, or has been hot, or is maybe even charred!

Using what we know so far, we can now talk about some simple circuits.
