Measuring appliance power consumption

Paul Rako - March 07, 2017

Most engineers like to be efficient and conserve. To that end I bought two ac power meters. For handy instantaneous measurements, the Kill A Watt is a nifty device (Figure 1). It gives an instant readout of anything you can plug into the wall. It does have an integrating W-hr capability, but it does not record anything or transfer measurements to your computer. It displays voltage, power, amperage, power factor, frequency, volt-amps, energy, and elapsed time.

Figure 1 You can connect any 120V ac plug into the Kill A Watt and it will read out power usage as well as power factor and other parameters.

The one thing the Kill A Watt does not do is log the data and let you download it into a spreadsheet or graphing program. For 20 bucks you can’t expect too much. For data logging I use a Watts Up? Pro (Figure 2), now discontinued. With the tiny power meter chips made by Microchip, Analog Devices, ST, Atmel, Silergy, and others, I would hope someone would make a logging meter that fits
in a small socket. The $110 Watts Up? Pro is a bit arcane to use, but works OK. I wanted to see the power usage of my Maytag refrigerator, the same one that had an icemaker switch fail. After a bit of poking and prodding, I got the Watts Up? Pro set up, and let it take data for a couple hours (Figure 3).

**Figure 2** The Watts Up? Pro takes measurements like the Kill A Watt, but stores them in memory and lets you download hours of measurements to your computer.
**Figure 3** The Watts Up? Pro recorded the cycling of my Maytag refrigerator. The in-rush power approaches 900W, the running power is 200W, and the average power is 73W.

You can see the compressor in the refrigerator has a large in-rush power, about 900 Watts. After a second or two, it drops to 200W. The duty cycle is around 37%, so this means my refrigerator takes about 73W equivalent full-time. In Silicon Valley a 24/7 Watt costs around a dollar a year, so my fridge costs me around 73 bucks a year.

Be cautious when looking at that data. The fact that the peaks are not equal tells you that the data acquisition is too coarse; too few samples per second to accurately record the in-rush peak power. Indeed, a drawback of the Watts Up? Pro is that the fastest sample rate is 1 sample per second (**Figure 4**). You can see the peaks are too “pointy” at the top to represent good data. It is very likely the peak power is greater. You can also see the value of the power has a staircase as it gently declines to 200W. That shows the amplitude resolution limit of the Watts Up? Pro.
Figure 4 A close-up of the refrigerator motor turning on shows the 1-second sample rate is not really fast enough to capture the true peak power. You can see the power factor drop when the motor runs. Voltage and frequency are mostly stable.

I was delighted at being able to see my power usage over time. I plugged my printer into the Watts Up? Pro (Figure 5) and it showed an initial longer spike as the fuser roller heats up, and then spikes as each page comes out of the printer. Once again, the pointy un-equal spikes mean the sample rate is not fast enough. The good thing is how little power the printer uses when it is idling.
Figure 5 A Brother printer uses nearly 1200W as it prints out a series of pages.

It’s hard to see the idle power with this chart, so you can kick the Y-axis into a logarithmic scale (Figure 6). This makes it easy to see the idle power is about 12W, and note it drops to 10W right at the end. Doing the same log-scale trick on Figure 3 lets you see more detail as well (Figure 7). Now you can see the Maytag fridge has an idle power of about 3W.

Figure 6 The printer power usage displayed with a log scale let you see the idle power is a bit over
Figure 7 The refrigerator power displayed with a log scale shows a small but measurable idle current of 3W.

These meters taught me a lot. One big deal was that I saw that my Denon receiver had a large quiescent power--over 120 Watts. That was with no signal. Texas Instruments amplifier application engineer Paul Grohe explained it: “Those modern receivers have a DSP chugging away to do tone control and reverb and other ‘features.’ Even with no output they still use a lot of power.” My old analog Sony stereos used less than 10 Watts when they had no signal. I turn off the Denon when I go to sleep now. Grohe remarked that set-top boxes were even worse. Since the cable and satellite companies want a cheap box, they don’t care what you pay for electricity. The problem with that is turning off your set-top box is a major hassle. You would need to wait many minutes for all the data to download to it before it works right.

The Kill A Watt was a handy, cheap tool. Years after I bought these meters, PG&E put in a smart meter with an LCD readout of power. I was amazed--hundreds of Watts when I thought I had everything turned off. It was all that vampire power from a few dozen wall warts, and the quiescent power of the TVs. I started using a plug strip on the entertainment center so I could just cut off ac power to all the units. There was still 10 watts I could not find. Grohe solved that mystery, “Oh, if you have unplugged everything, than that power is the transformer on your furnace.” I guess I can live with those few Watts, even if it costs me 10 bucks a year.

Also see:
- Reduce your electricity bill - start with an efficient A/C design
- A mid-range approach to home-energy saving
- Power factor correction devices: Can they really reduce your electricity bill?
- Offline converter stops vampire-power waste