Squeezing Out the Last Drop

How to make your electronic devices even more energy efficient

By Fons Janssen and Mark Vermeulen (The Netherlands)

You've replaced all your incandescent lamps with energy-saving lamps. Your TV set is never in standby mode, and you're giving serious consideration to having a solar panel installed on your roof. What else can you do to reduce your power bill without too much fuss and bother?

It's not especially difficult to determine the standby power consumption of the electrical equipment in your house (see the article 'Economical with Energy' in the January 2008 issue of Elektor), but even if you know that your WiFi router consumes a steady 6 watts, what can you do about it? Pulling the plug when you're not actively online is rather impractical. Fortunately, there are several other approaches that electronics enthusiasts can use to reduce standby power consumption.

What ends up where?

In this article we concentrate on equipment that is normally left on 24 hours a day, 7 days a week. A good example is the previously mentioned WiFi router. This sort of equipment usually operates from a low voltage and is powered by an AC adapter. This is usually an off-the-shelf model, with the result that the adapter and the device it powers are not optimally matched. In addition, many of these adaptors still use an inexpensive iron-core transformer, which is not especially efficient.

As a practical example, let's consider a WiFi router with the Sitecom brand name. It is powered by a 12-V AC adapter ('wallwart') included with the router. The power consumption measured using a power meter is 6.2 W, which yields an annual energy consumption of around 54 kWh. If you open up the router (**Figure 1**), you see that the 12-V input voltage from the adapter is immediately reduced to 3.3 V by a buck converter built around an AP1510. If you replace the

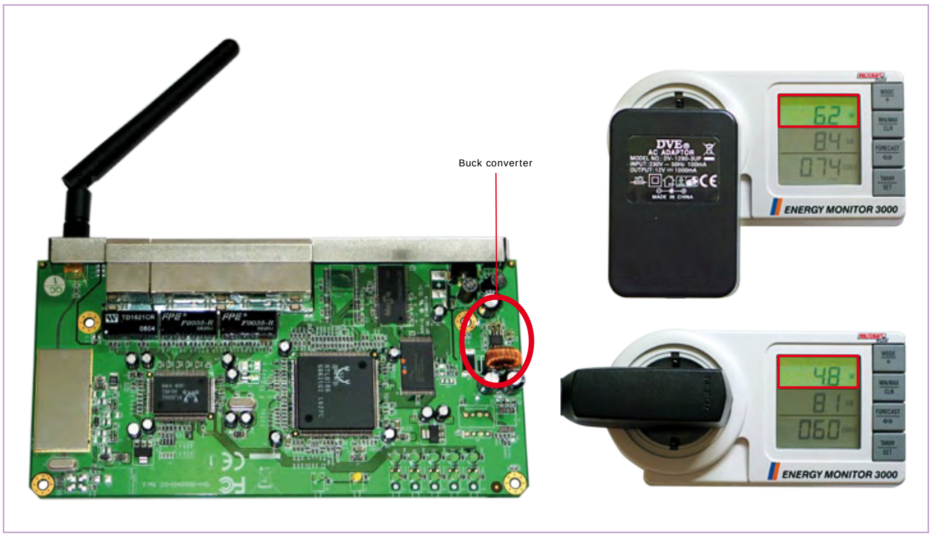

Figure 1. A look inside the WiFi router. The external supply voltage is reduced to 3.3 V by a buck converter. The power consumption of the router can be reduced by around 1.4 W by replacing the AC adapter included with the router by an adapter with an electronic converter. However, it should be noted that the phase factor of the electronic converter is somewhat lower, with the result that the reactive power of both adaptors is virtually the same. Of course, the kilowatt-hour meter in the meter cabinet registers only the real power.

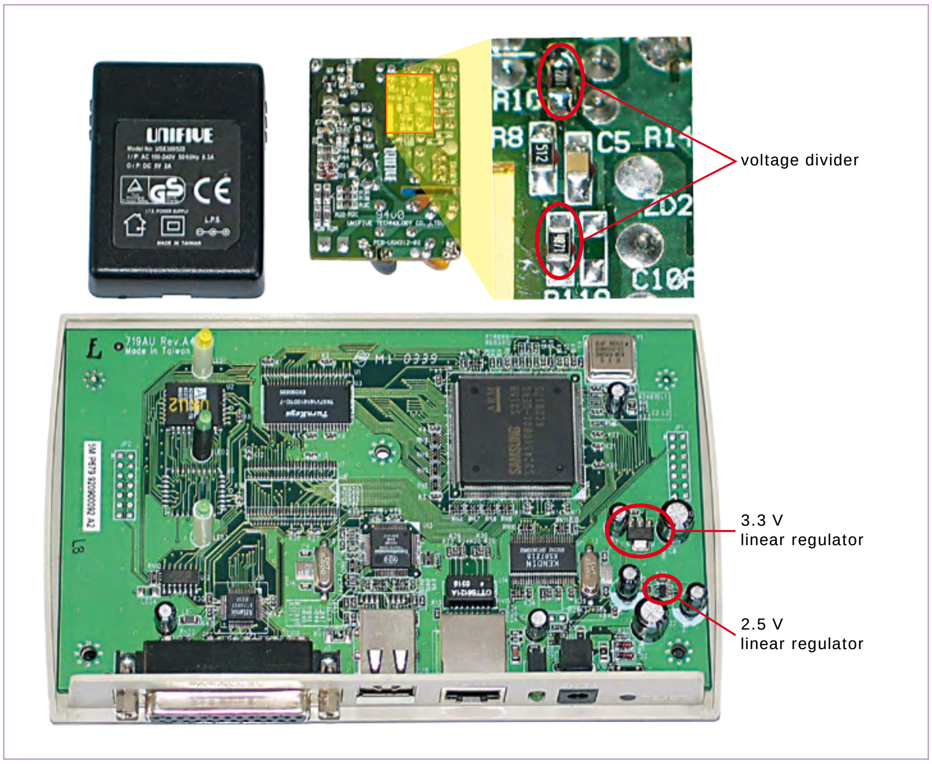

Figure 2. The motherboard of the printer server (bottom) and the included AC adapter (top). The output voltage of the adapter can be reduced from 5 V to 3.6 V by replacing the upper feedback resistor with a 2.2-kΩ resistor. The motherboard has two linear voltage regulators that can operate perfectly well with an input voltage of 3.6 V. The USB bus voltage is also reduced to 3.6 V, but printers are generally not powered from the USB port, so this does not have any detrimental effect.

adapter with a laboratory power supply, you can see that the current consumption is only 250 mA, which corresponds to 4 watts. This means that the adapter consumes around 2.3 watts of the total 6 watts you pay for. In addition, the adapter is distinctly heavy, which indicates that it uses an iron-core transformer instead of an electronic voltage converter.

A more economical adapter

The first thing you can do to reduce the power consumption is to replace the adapter. As the input voltage range of the buck converter in the router is quite large (3.6 V to 23 V), nearly any adapter can be used. We chose an electronic adapter for a mobile telephone no longer in use. It supplies 5.7 V with a maximum output current of 800 mA, which is well over 4.5 W. If you switch on the router with this adapter, the power meter indicates a consumption of 4.8 W, which represents a savings of 1.4 W. This may not seem like all that much, but on an annual basis it adds up to well over 12 kWh. In most countries that's enough to run your clothes dry around twelve times.

Voltage adjustment

Unfortunately, using an electronic adapter is not the solution to every problem. For our second practical example, we examined a no-name USB printer server. You can use it to connect a printer directly to your network without using a PC as an intermediary. This by itself yields considerable savings, since you don't have to leave your PC running 24 hours a day. The AC adapter included with the server looks perfectly fine at first glance. It is a lightweight model rated at 10 W output power, which unquestionably means that it uses an electronic converter. However, if you look at what happens to the 5-V supply voltage from the adapter after it enters the server (**Figure 2**), you see that the power savings achieved by the electronic converter are all for naught: the 5-V supply voltage is reduced directly to 3.3 V and 2.5 V by a pair of linear voltage regulators. This means that a good deal of the power supplied by the adapter is dissipated as heat in the voltage regulator ICs. If you can reduce the output voltage of the adapter to 3.6 V (600 mV of headroom should be enough

for the linear voltage regulators), you can achieve considerable savings.
Almost all power supplies use a voltage divider to set the output voltage, according to the formula

$V_{out} = V_{ref} \times (1 + R1/R2)$

This means that you only have to replace one resistor in order to reduce the output voltage of the adapter. If you open up the AC adapter here, you can see right away that it is an isolated resonant flyback converter. The voltage divider is present as expected, and it is used in combination with a shunt regulator (SE431) with a 2.5-V reference voltage. Here R1 and R2 have nearly the same values (4.9 kΩ and 4.87 kΩ), so the output voltage is 5.05 V (2.5 V × (1 + 1.02)). To reduce the output voltage to 3.6 V, all you need to do is to reduce the value of R1 to 2.2 kΩ.

The result is exactly what you want. Before the modification, the meter indicates a power consumption of 4.3 W, and after the modification this drops to 2.7 W. This represents a savings of an impressive 37%, which amounts to around 14 kWh on an annual basis.

Can you take this even further? The answer is yes. In particular, it would be nice to be able to switch the device off entirely during idle periods. Of course, you could use a simple timer switch for this, but it has the same switching times every day and does not take weekends into account, not to mention summer and winter time. In another article in this issue, we describe an intelligent timer switch that does take weekends and summer/winter time into account and consumes almost no power. Thanks to its compact dimensions, it can even be built into the device it controls.

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