Standing By Efficiently

Example of Bias power supply module shown for size comparison.

Fresh ideas for designing power circuits can reduce energy use.

by michael creighton

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Anyone who has been around the appliance or consumer electronic industries long enough will remember when there was a public outcry about the early, wasteful "instant on" solid-state televisions. A low-voltage kept the CRT heater warm and ready to go at the expense of a small, but constant, power drain. The industry responded with a more efficient solution, quick-start CRTs, and the discussion ended.

What is creating a sense of déjà vu is the growing awareness of today's "vampire" products that also continue to suck up power when the appliance power switch is off. This time it is not a CRT that's consuming sleep-time power, it's the system clock, touch-control circuitry, IR remote receivers, sensors, and even message displays.

Is this really a problem? Individually this drain doesn't amount to much, but cumulatively, standby power usage can add up. Estimates range from 15 percent to 40 percent as to how much household energy usage can be attributed to inefficient standby power circuitry in home appliances and consumer electronics. With utility rates rising, more consumers are taking notice of this added cost. Without question, that issue is influencing their product selections.

For some years, there has been an international movement to design appliances and consumer electronic products to consume no more than 1 watt of power when in the "off" mode. In the U.S., the Energy Star program has made many great strides in voluntary compliance, with a growing number of appliances qualifying for an Energy Star badge.

Solutions

It is no secret that the power supply is often an afterthought in product design. As a result, appliances often end up with inefficient standby power supplies and inefficient circuitry design, as well. In these cases, the power supplies continue to deliver power in standby mode to circuits that don't need to remain on. What this means is that some level of concurrent engineering is required between the circuit designers and the power supply engineer. If those happen to be the same person, concurrent thinking is needed.

The first step in designing for low, standby-power consumption is to isolate which circuits truly need power in standby mode. This is not as straightforward as one might expect, and it might require some rethinking of power distribution, or even what voltage levels are circulating within the product.

Typically, the next issue is the power supply itself. There are traditional choices, but some fresh thinking may be required. Selection issues include:

- The build vs. buy question. This involves comparing the cost of buying an off-the-shelf (or customized) power supply vs. designing and building one from scratch. When weighing the costs of both approaches, it is important to consider factors such as design and testing time, procurement time, component inventory, etc.
- Combination standby/main power supply vs. individual power supplies. This evaluation can also be a bit tricky. Some off-the-shelf power supplies provide the functionality of both main power supply and standby supply. These are more costly than standard switch-

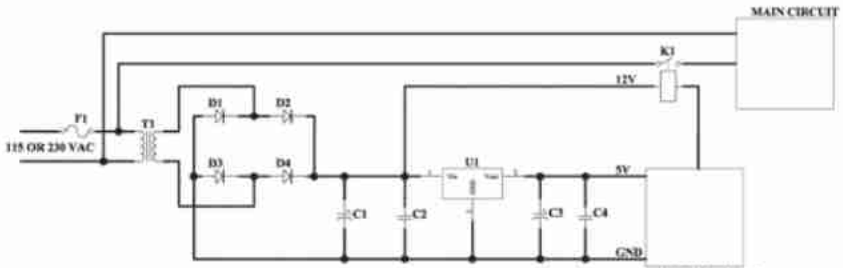
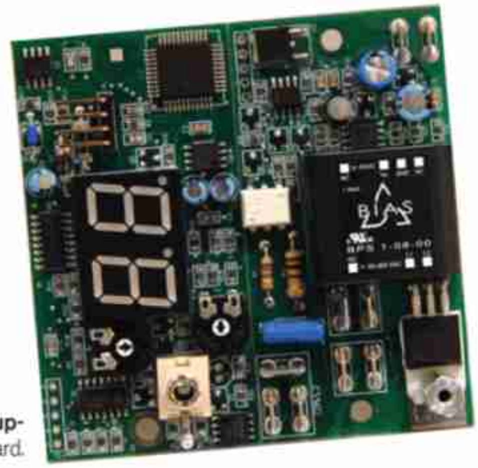


Fig. 1. Original linear power supply design.


Example of how a Bias power supply module fits on circuit board.

ing supplies and may be more expensive than separate main and standby supplies. In some cases they are also less efficient in standby mode than a separate standby supply.

- Other choices. There may be other design choices to consider, such as building a power supply around a functional block, with an IC combining various power supply functions.

Probably the worst solution is using a conventional main power supply for when the product is in a standby mode. The reason is that, while the efficiency of such a supply may be quite high near its rated load, it is usually poor at lower power levels — often falling below 50 percent. Published data shows that some switching power supplies that normally operate at 70 percent efficiency or greater can drop to under 45 percent when their load is at 10 percent of rating. This is further complicated by the fact that switching power supplies with a higher power than necessary are often specified to maximize reliability. Efficiency curves of power supplies vary, but in general, a power supply is designed to achieve its best efficiency at a given load, and that efficiency will decline as the load gets farther from that point.

The much more complex standby/main power supplies may be an acceptable solution for a high-cost industrial product or a commercial vending machine, but the cost may be difficult to justify in a high-volume, consumer appliance.

Separate approach

The goal of Bias Power at its founding was to create a highly efficient, highly reliable low-power, switching power supply that would be especially well-suited for standby and Energy Star applications. Other attributes considered important included universal power input (85 VAC to 265 VAC, 50/60Hz), PCB mountability, and a very small form factor. A couple of product generations later, that goal had been fulfilled with 1/2-Watt, 1-Watt and 2-Watt models. Higher power and other variations are also in development.

The patented Bias design requires no external EMI/RFI filtering because products incorporate a proprietary technology that greatly reduces the generation of EMI. The levels achieved are within the limits specified in FCC Part 15 and EN 55022, Class B. All Bias modules are UL Component Recognized to 60950, which also simplifies their application.

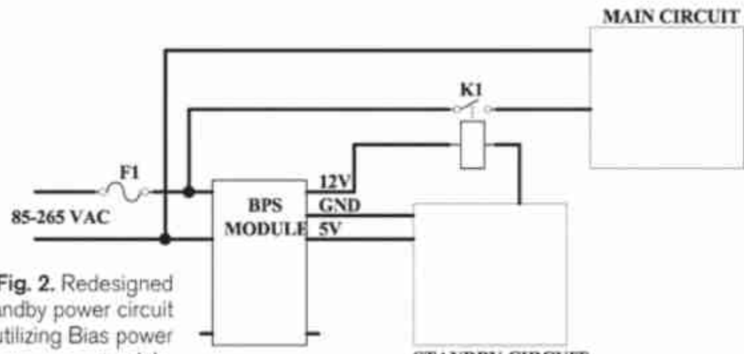


Fig. 2. Redesigned standby power circuit utilizing Bias power module.

Case study

Bias Power teamed with a manufacturer of household appliances with the goal of reducing standby power and meeting Energy Star certification requirements in one of its products. The design challenge was threefold:

- Reduce the power consumption in standby mode from an existing 3.8 Watts to less than 1 Watt.
- Implement universal input capabilities.
- Reduce overall PCB size, if possible.

Achieving UL/CSA and EN safety approvals, and FCC class B compliance for both radiated and conducted emissions were also important factors.

The original design employed a standard linear power supply that included a transformer, bridge rectifier, linear regulator and discrete devices for filtering and over-voltage protection. ***(See Fig. 1.)*** Separate SKU's were required for domestic 120 VAC/60Hz and international 220 VAC/50Hz products.

The original control circuit design was very traditional, and not designed for standby optimization. The design included an RF control receiver, three relay coils, and control circuitry to activate the main power once requested by the user. After reviewing which circuits actually needed power in standby mode, it was determined that a new power path would be needed. ***(See Fig. 2.)*** This required a new PC board layout to separate the main system power from the standby power circuits, which must be separately powered 100 percent of the time by the standby power supply. For simplicity, it was also necessary to redesign the components in the standby section to have a uniform operating voltage of 12 VDC.

The system power requirements were 150 mA for steady-state operation, with an initial inrush requirement of 400 mA for 1 microsecond. During sleep mode or standby, when the unit is not in operation, the system required 40 mA to be alive to sense and respond to RF transmissions for power "ON" requests.

A 2-Watt, off-the-shelf Bias Power module was selected to satisfy the 150 mA power requirement, handle the inrush demands, and be efficient enough to satisfy the less than 1-Watt Energy Star requirement. Unlike conventional power supplies, power requirements of the Bias modules are very low with little or no load. When the appliance is in standby mode, the power consumed is now 14 V (Bias Nominal) x 40 ma = 564 mw with a measured input power of 831 mw yielding a 67.8 percent efficiency. In other applications, the efficiency

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could be even higher.

The new power supply provided the significant benefit of universal input: 85 VAC to 265 VAC 50/60Hz. This covered the global power requirements and reduced the number of control board SKUs needed for a single design. The physical space required by the Bias supply was less than 35 percent of the original power supply. Projected reliability increased and inventory requirements were simplified, as the component count dropped from 13 discrete devices to a single PCB-mountable solution. This redesign project met all of the performance goals, while actually lowering costs.

Conclusion

There are many other ways to alter the design of circuitry that must be energized in standby mode; and it is likely that significant additional power savings can be achieved with some of them. The thrust of the previous example is merely intended to increase awareness among design engineers of the benefits of designing products for low standby power consumption, and ideally Energy Star certification.

When approaching a redesign or new design, engineers should audit which circuits must be live in standby and route power accordingly. They should utilize a separate, high-efficiency source for standby power and not attempt to power both main and standby circuits with a common single-function power supply. They should also consider what additional benefits may be introduced at the time of the redesign, including improved reliability, universal power input, reduced board or product size, and simplified inventory. ■

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