Supplanting linears

Designers have many reasons to replace line-transformers in their applications

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Despite the emergence of cost-effective alternatives, many OEMs have persisted in using line-frequency transformers (linears) in low-power battery chargers and ac adapters. This is largely due to inertia, as many OEMs have taken an "if it isn't broken, don't fix it" attitude toward their power supplies, despite the obvious size/weight advantages of switchers.

Opening photo

However, because of their high eddy-current and winding-conduction losses, existing linear designs generally fail to comply with upcoming mandatory energy-efficiency standards for external power supplies. In the resulting redesign cycle (which is already well underway), manufacturers will be inclined to choose switched-mode designs for two reasons.

Most important, designing linears to comply with the standards is likely to be cost-prohibitive if not impossible. Second, linears have several disadvantages—in addition to size and weight—that OEMs have tolerated in the past simply to avoid the redesign process. Given an impetus to change anyway, designers can use these disadvantages as additional reasons to choose switching technology.

Limited input-voltage-range operation

The primary drawback of line-frequency transformers is that their output voltage varies directly (linearly) with their input voltage, which means that to deliver a consistent output voltage, the range of input voltage variation must be kept very narrow. Because so many different line voltage ranges exist around the world, separate transformers are required.

Even when a linear is designed for a specific region, such as the U.S., the output voltage of the transformer is often unacceptably high or low within the normal range of line voltage variance. For example, a linear designed to deliver 12 V when the input is 120 Vac will only put out 8.5 V at low line (85 Vac).

Likewise, the same transformer will supply 13.5 V at high line (135 Vac). That is an output voltage tolerance of 12.5% and –29.2%—hardly a practical range for electronic circuitry to work from. Thus linear supplies must have a regulator downstream from the transformer to control the voltage and/or current delivered to the load.

By contrast, most IC-based switchers work over a very wide (universal) input voltage range. Able to work from a line voltage as low as 50 Vac and as high as 275 Vac, an IC-based supply can be used worldwide.

With only one model of each power supply to stock, the inventory and warehouse space reduction can result in significant cost savings. Those savings alone could warrant adopting IC-based switched-mode power supply (SMPS) solutions.

One-time thermal fuse

Applications that use external chargers and adapters–such as cordless phones, baby monitors, toys and small cordless tools and appliances (such as handheld vacuum cleaners and screwdrivers)—have power management built into their on-board electronics. However, they still need a front end that steps down the ac line voltage, rectifies it into dc, and offers protection from overheating, fire, or electric shock if a fault occurs.

Linears typically use one-time thermal fuses to protect against overheating. Although these fuses have helped to make thermal protection a nonnegotiable industry-wide safety requirement, they have a significant disadvantage in that the charger or adapter is rendered unusable and must be replaced after a fault trips the fuse.

On the other hand, the auto-recovering thermal protection function found in some IC-based switchers allows the supply to resume normal operation once the cause of the overtemperature condition has been removed. This can significantly reduce the number of field returns that occur simply because a jacket or blanket was inadvertently thrown over a brick that then overheated and failed. A lower rate of returns not only reduces the cost of RMA (Returned Material Authorization) processing, but also reinforces a perception of higher quality and reliability by the consumer.

Linears' cost advantage has vanished

Finally, cost alone would eventually cause most line-frequency transformers to be replaced by IC-based SMPS solutions. With the costs of copper and iron rising, and the cost of ICs coming down, linears have lost their low-cost advantage.

Adding cost in an effort to make linears meet the energy-efficiency standards is simply not a viable option; thus the energy standards appear to be the stake in the heart of these "energy vampires." Fortunately, IC-based SMPS can now be designed to deliver power with an output voltage/current characteristic similar to that of the linear, avoiding the need to redesign the power management functions inside the product and eliminating a possible deterrent to converting from linears to switchers.

Another obstacle that has kept transformer designers from embracing switching technology has been the aura of black magic that has surrounded the design of high-frequency SMPS transformers. With this in mind, as an example Power Integrations has designed two standard high-frequency transformers that work with their LinkSwitch-LP family of ICs, which are specifically designed to replace linear transformers.

These standard transformers can be ordered as commercial off-the-shelf parts from several manufacturers, effectively allowing a transformer engineer to skip the learning curve associated with designing high-frequency transformers and to quickly produce SMPS solutions. The artwork for a supply's pc-board layout is also available, so designers can quickly and easily produce myriad solutions with numerous output voltage and current ratings. These solutions can then be rapidly moved through design verification testing and into high-volume manufacturing.