Switcher ICs Reduce Power Consumption, Simplify Design for Smart Home & Appliances

The number of connected devices in the “smart home” – including televisions, lights, doorbells, and appliances – is growing exponentially each year.

Introduction

Annual shipments of smart devices are well into the billions. Not only are there more products on the market, but they also contain far more features than previous generations of similar products, where the functions were often simply "on" and "off."

Unlike traditional electronic end products, smart devices often remain in an "always on" mode even though it may appear that they are powered down. These products are constantly consuming power, so standby power consumption is a crucial specification.

Even though each individual device may only consume a small amount of power, when you add them all up, power consumption is significant. The average home contains around 40 devices that are constantly drawing power [1]. "Sleeping" devices can account for as much as 10% of a household's total energy consumption, even though many remain in sleep mode for up to 90% of the time.

Regulation compliance is not the limit

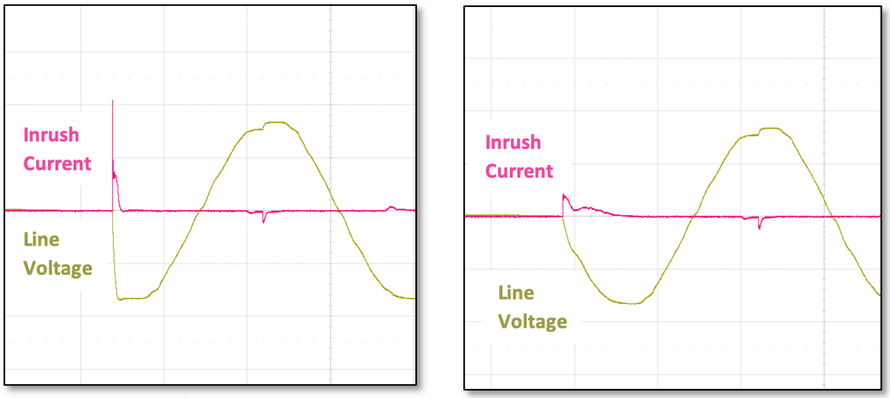
While regulations are in effect, performance can be improved considerably and greatly benefit the consumer. For example, the U.S. government specifies that its own federal agencies must purchase energy-consuming products with a standby power level of 1 W or less [2], when compliant models are available. If consumers were to follow that same rule, they could be continuously burning more than 20 watts, based on the above statement that the average home contains around 40 devices that are constantly drawing power.

The ENERGY STAR® program did a great job reining in white goods and larger appliances, but it did little to address the exploding market of IoT connected devices [3]. As stated above, individual device standby power may be relatively low, but cumulatively it can be significant.

Let us review a smart television as an example. It is designed with Wi-Fi, which is always on, and in most cases uses an isolated power supply. During light loads and in standby, the typical efficiency range of the power supply is in the range of 50% to 75%, reducing the available output power to only 500-750 mW when meeting a 1 W standby requirement.

Zero-cross detection

One method of reducing power loss and efficiently managing the power fed to AC loads is by implementing zero-cross detection. This circuitry "detects" the zero-crossing point of the AC voltage and uses this to control relay switching (either IGBTs and TRIACs) to minimize switching stress and system in-rush current (Figure 1). In many of these applications (i.e., hot-switching applications), the AC line is connected to a relay. If switching is not synchronized, you end up with a large in-rush current, which has a detrimental impact on the lifetime of the relay.



Without ZCD
Peak inrush current = 103 A

With ZCD
Peak inrush current = 21.8 A

Figure 1. Zero-cross detection (ZCD) provides a logic signal when the AC voltage passes through 0 V. These charts show the inrush current level with and without zero-cross detection.

To soft-switch or zero-voltage switch the main power device, the zero-crossing signal is synchronized to the AC line. Zero-cross detection is integrated into Power Integrations' LinkSwitch™-TNZ switcher IC family, where detecting the zero-cross point consumes less than 5 mW. As a result, system standby power can be significantly reduced compared to conventional circuits that require multiple discrete components, such as line-drop resistors, and consume up to 100 mW of continuous power (watch the video explaining how this works). This conventional approach can be quite lossy, consuming almost half of the standby power budget in some cases.

The X-capacitor discharge

The IEC 62368-1 standard merges IEC 60065 (the electrical safety standard for audio, video, and similar equipment) and IEC 60950-1 (the standard for electrical equipment for information processing, office machinery, and telecom equipment). Although it combines these two previous standards into a single document, IEC 62368-1 represents significant departure from the previous standards. Instead of being based on requirement descriptions, this safety standard focuses on judging the injury risks during operation giving manufacturers greater leeway in deciding how to design-in protection. The standard divides a product's safety risk into three levels. Based on these levels, the standard then has a definition of what constitutes an acceptable voltage in each level, and consequently what type of protection is required.

That leads us to a second key feature of the LinkSwitch-TNZ: an integrated X-capacitor bleeder, which is connected directly to the AC line across the input filter. Its purpose is to automatically discharge the X-capacitor and protect the user from an electrical hazard. The voltage across the X-capacitor must be discharged to below 34 V in less than 1 second to pass the safety standard. Note that not all applications require an X-capacitor. The X-capacitor discharge feature eliminates the conventional protection approach provided by permanently connected bleeder resistors, further reducing standby power consumption. At the same time, the IC's lower power consumption enables the use of a larger value X-capacitor, which helps reduce EMI while retaining the low standby power.

Without a device like the LinkSwitch-TNZ, three separate ICs would be needed – one for the X-capacitor discharge, one for the power supply and one for the zero-crossing detection. LinkSwitch-TNZ performs these of these functions with a single device.

No-neutral wiring

LinkSwitch-TNZ ICs support "no-neutral" wiring. The neutral wire is for carrying the return current and the ground wire is intended as an alternative return path for current in the event of a ground fault (Figure 2). However, many existing wall switch sockets do not contain the neutral wire, particularly where switches are being retrofit into older homes. When a mechanical switch is deployed, that no-neutral configuration is sufficient.

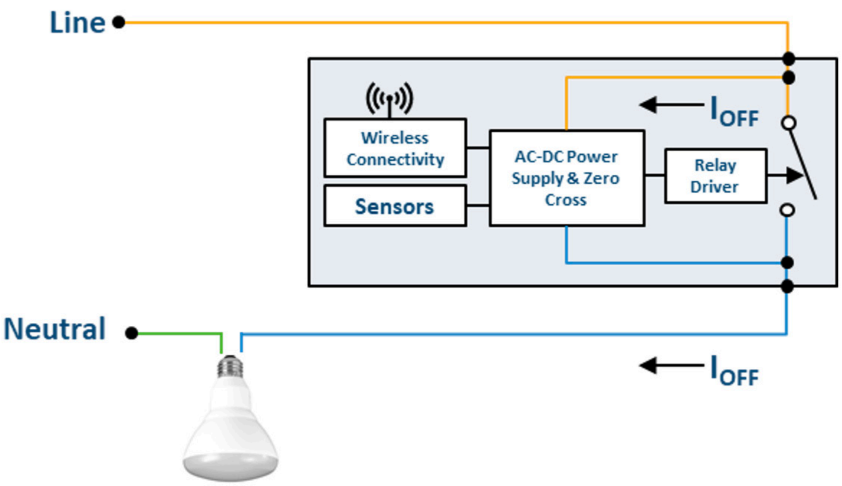


Figure 2. Some older homes may not have access to a neutral line. Using the LinkSwitch-TNZ, means that is not an issue.

That is the challenge presented even to the latest smart dimmers and switches. LinkSwitch-TNZ ICs provide power to the switch control circuitry and do not process the load current directly. The switching devices are sized to support the equipment load. LinkSwitch-TNZ can support switching devices that service loads ranging up to 250 W. Leakage is less than 200 µA at 230 V. As a result, it prevents ghosting and flicker with LED loads. This feature also allows the circuit to pass the UL773A 500 µA limit for GND leakage current. Finally, the family supports leading- or trailing-edge dimming, as demonstrated in design example DER-865.

Scalable power matches application requirements

The LinkSwitch-TNZ product family consists of eight devices that cover isolated (flyback) and non-isolated (buck) applications across a range of power levels. Note that many home-automation applications do not require an isolated power supply because the switch socket provides suitable isolation.

As stated earlier, the savings realized by one switch may seem inconsequential. However, because of the high volume of switches per home and the number of homes in a grid network the overall savings are substantial.

References

[1] Lawrence Berkeley National Laboratory (https://standby.lbl.gov/)

[2] U.S. Federal Energy Management Program (www.energy.gov/eere/femp/low-standby-power-products)

[3] Energy Star SHEMS (Smart Home Energy Management Systems)
(www.energystar.gov/products/spec/smart_home_energy_management_systems_pd)

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